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A METHOD OF EXTERNAL IRRADIATION OF THE AXILLA[1]

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IRRADIATION of the axilla for metastatic carcinoma of the breast has been a routine procedure in many institutions since the acceptance, by the medical profession, of roentgen radiation as a means of treating malignant tumors.

Interstitial irradiation, by means of long needles containing radium element, and gold wires and seeds containing radon, has been used with varying success by a number of men. This method has not met with universal acceptance. However, practically all tumor clinics employ x-rays in the irradiation of the axilla for the treatment of metastatic breast carcinoma. Some treat the axilla only in inoperable cases, others use the treatment as an adjunct to surgery, either before or after operation, or both before and after operation.

It is not within the scope of this paper to discuss the indications for axillary irradiation, but an attempt is made to present a logical and effective method by which external radiation may be given. The problem here, as in most cases of external irradiation, is to deliver the largest dose possible to the tumor-bearing area, with the minimum amount of trauma to the skin and other vital structures within the field of radiation.

Various methods of axillary irradiation have been employed at the Memorial Hospital. These methods may be defined, according to the number of ports employed, as follows:

(1) *Two Ports.*—One port anterior, and one port posterior, employing large fields up to 20 × 20 centimeters.

(2) *Three Ports.*—The anterior and posterior ports as above, but smaller, with an additional port directed into the axilla, with the arm in abduction.

(3) *Four Ports.*—Same as the three-port, with an additional superior port to the supraclavicular region, directed downward toward the axilla.

(4) *Five Ports.*—The above four ports, plus an extra port, directed toward the axilla through the lateral surface of the adducted arm.

The five-port method was soon discarded because it was found that, by irradiating through the lateral port with the arm adducted, a fold of the skin covering the axilla lay in the field of irradiation, causing this portion of the skin to receive an additional dose of radiation on the area already irradiated. This should be avoided, as the skin of the axilla is especially sensitive to radiation trauma because of constant friction, and moisture from perspiration.

In an attempt to discover the method which would give the greatest dosage of radiation to the axilla, measurements of

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

the axillæ were made on 50 cases of carcinoma of the breast, the unaffected side being measured. From these measurements, the size of the ports and the delivered dosage were computed. These measurements were made as follows:

(1) From the lateral surface of the arm to the axillary fold (this varied but little, being 8 cm. in most cases).

(2) From the axillary fold to the sternoclavicular junction. (This gives the transverse dimension of the axilla, as the axillary fold denotes the lateral surface of the axilla, and the apex is at the point where the large vessels dip under the clavicle, at the junction of its middle and medial thirds.)

(3) Anteroposterior at a point one-half the distance between the axillary fold and the apex of the axilla, on a line from the apex to the insertion of pectoralis majoris muscle, a line which represents the course of the great vessels. The point of intersection of the lumen of the axillary vein, and a line perpendicular to the transverse body plane drawn through the point of the anteroposterior measurement, represents the approximate center of the axilla.

(4) Vertical, from the central axillary point to the shoulder surface.

(5) The estimated thickness of the panniculus adiposus, overlying the skin of the axilla. This in each case was estimated to be about the same at 1.5 cm., and varies with adduction and adduction of the arm. With the arm in extreme abduction, the mid-point of the axilla lies about 3 cm. from the skin, a measurement which varies little with the adiposity of the patient.

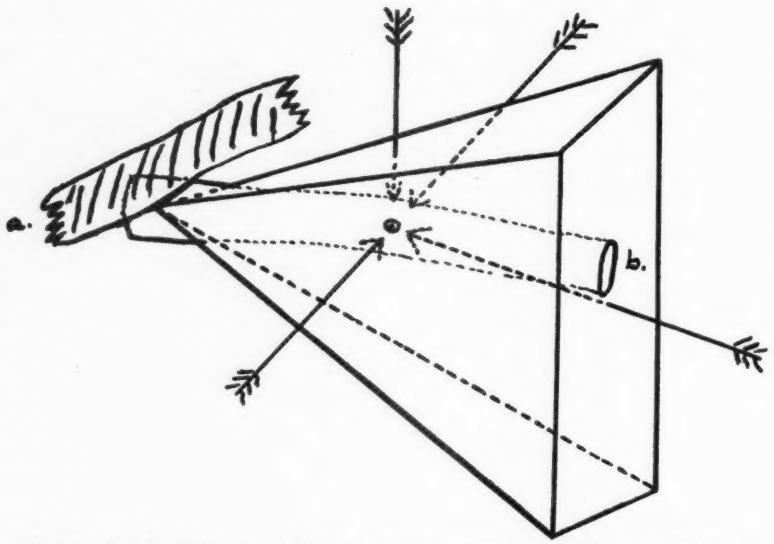

Fig. 1. A schematic representation of the axilla. The arrows indicate the direction of the beam for the different ports. (*a*) is the clavicle, (*b*) the axillary vein, and (*c*) the mid-point of the axilla.

The mean of the axillary measurements of the 50 cases was taken, and a cadaver obtained with measurements as nearly as possible identical with the average of the cases already measured. A careful dissection was made of the axilla, removing all of the axillary contents with the exception of the large blood vessels and nerves. With the arm in adduction, the dissected cavity was filled with plaster,

the resulting cast representing the axillary contents. The cast was found to have the approximate shape of a rectangular pyramid, with the axillary skin for its base (Fig. 1).

As the route of metastasis follows the lymphatics accompanying the axillary vein, the center of the tumor-bearing area is approximately the center of the axilla described above. This is the point on which the centers of the beams of radiation are directed. Measuring from the various skin surfaces to this point, the measurements in Table I were obtained.

TABLE I.—SHOWING DOSAGE OF RADIATION DELIVERED TO AXILLA THROUGH VARIOUS PORTS

Portal	Distance to mid-axilla	Dimension of portal and percentage S.E.D. to axilla
Anterior	3.0 cm.	10 × 10–85% 20 × 20–90%
Posterior	10.0 cm.	10 × 10–35% 20 × 20–40%
Direct, arm abducted	3.0 cm.	10 × 8–80%
Superior	5.5 cm.	8 × 6–60%

The first axillary measurement is the thickness of the arm to the central point of the axilla, a fact which shows that this distance to the axilla, through a lateral port with the arm in adduction, is too great for an effective dose to be delivered into the axilla, even if the over-radiation of the axillary skin is disregarded. The second measurement, from the axillary fold to the sternoclavicular joint, varies with the size of the thorax and was used to aid in the determination of the size of the mean average axilla, and in the selection of an identical cadaver measurement. The anteroposterior measurements show that the center of the axilla lies only 3 cm. from the skin anteriorly, but 10 cm. posteriorly. The vertical distance averages 5.5 cm., and the lateral distance, with arm abducted, 3 centimeters. Thus, the axilla is nearer the superior surface of the thorax than it is generally thought to be.

At the same time the axillary measurements were being made on the 50 cases of breast carcinoma, the determination of the size of the skin ports was done, the desire being to use the largest ports possible without overlapping on the skin. This was accomplished by cutting from cardboard a number of rectangles and squares of various dimensions, and placing them on the skin so as to cover the largest areas possible over each port of entry, without overlapping of the radiation beams. Table I shows the size of ports adaptable to the average case. The 20 × 20 cm. ports were previously used when only two ports were employed, and included both the supraclavicular and anterior axillary regions. With small ports, a separate beam of radiation is directed to the center of the supraclavicular region.

A model of the axilla and of the large vessels was made and mounted. In Figure 2, the size of the ports, with their relative distances to the mid-axillary point, are shown, all ports being large enough to cover the entire axilla. The margins of the axilla, being in a peripheral portion of the radiation beam, receive somewhat less radiation than the central point, which receives more scattered rays. In this model, the direct port is not shown, as the cast was made with the arm in adduction. The model of the axilla would be of an entirely different shape if the cast were made with the arm in abduction. With the size of the ports and the distance to a given point being known, it is a simple matter to determine the dosage delivered. Table II is a depth dosage chart showing the measurements.

TABLE II.—SHOWING DEPTH DOSAGE OF VARIOUS SKIN AREAS, 100 PER CENT DOSES BEING DELIVERED TO THE SKIN SURFACE; 200 K.V. AT 50 CM. DISTANCE, FILTER OF 0.5 MM. CU AND 2.5 MM. AL.

Depth (Cm.)	Square Centimeters on Skin						
	25	50	100	150	200	300	400
	Percentages of S.E.D. Delivered						
0	100	100	100	100	100	100	100
1	98	99	100	100	100	101	101
2	88	92	94	94	95	95	96
3	78	81	85	87	88	89	89
4	66	70	75	78	79	80	81
5	55	62	67	70	72	74	76
7	40	46	51	54	56	58	59
10	24	28	33	36	37	40	41
12	18	21	25	27	28	30	31
15	11	14	17	18	20	22	23

These doses were measured in a water phantom, with a 200 K.V. x-ray machine at a target distance of 50 cm., and with a filter of 0.5 mm. Cu and 2.5 mm. Al. The measurements were made by Quimby and, according to recent comparisons, vary only slightly from readings made on a cadaver and on living tissues. The unit of measurement employed is the skin threshold erythema dose. This unit of measurement for external irradiation was developed by Quimby, Dean, and others, and may be defined as the amount of radiation sufficient to cause an appreciable reddening, and tanning of the skin from three to four weeks after exposure in 80 per cent of the treated cases, yet will not cause any noticeable change in 20 per cent. This threshold erythema dose is about 525 roentgens when given on the 200 K.V. machine at 50 cm. distance, with a filter of 0.5 mm. Cu and 2.5 mm. Al, on a 10 × 10 cm. port, to the external surface of the lower arm.

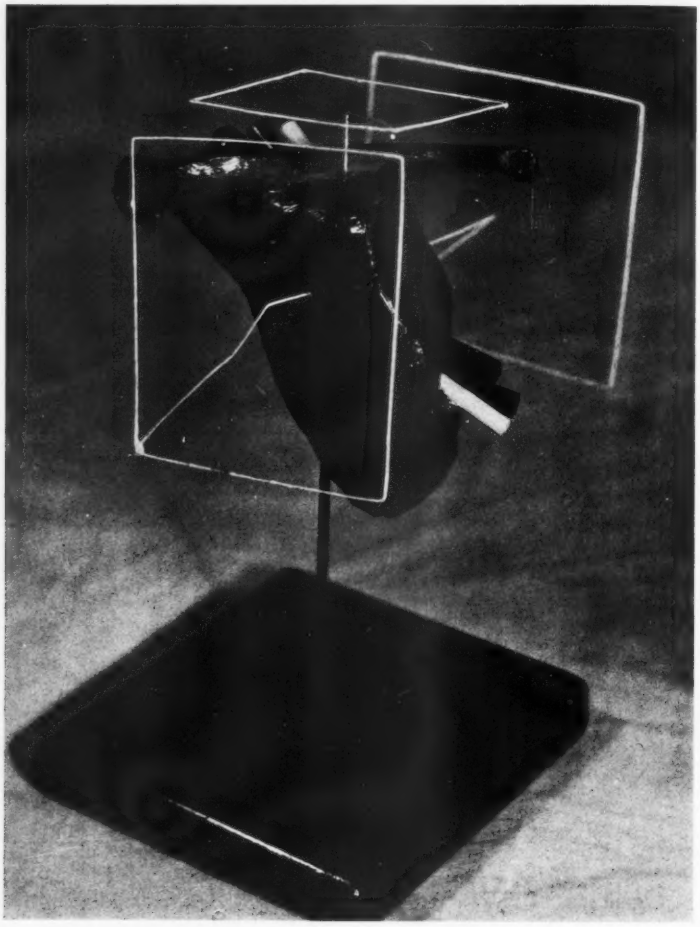

Fig. 2. Model of axilla, showing relative size and position of anterior, posterior, and superior skin ports.

It will be noted in Table I that if two 20 × 20 cm. ports are used, one anterior

TABLE III.—COMPARISON OF TISSUE DOSAGE IN CENTRAL POINT OF AXILLA, WITH VARIOUS NUMBERS OF PORTALS, AND DIFFERENT SIZES OF PORTS

Ports		Size	Total dosage	
Anterior	2 ports	20 × 20	90%	130%
Posterior		20 × 20	40%	
Anterior	3 ports	10 × 10	85%	200%
Posterior		10 × 10	35%	
Direct		10 × 8	80%	
Anterior	4 ports	10 × 10	85%	260%
Posterior		10 × 10	35%	
Direct		10 × 8	80%	
Superior		8 × 6	60%	

and one posterior, approximately 130 per cent T.E.D. will be delivered to the mid-portion of the axilla. The addition of the direct port necessitates the reduction of the size of the anterior and posterior ports, as the larger ports include the axillary skin in the cross-fire. When the size of these two ports is reduced to 10 × 10 cm., and the additional port of 10 × 8 cm. is added directly into the axilla, 200 per cent T.E.D. is delivered to the mid-portion of the axilla (Table III). When a beam of radiation is directed toward the axilla through an 8 × 6 superior port, 60 per cent of the skin radiation reaches the central point of the axilla, making a total of 260 per cent of a skin erythema in the central point.

These calibrations are made on the basis of 100 per cent S.E.D. being delivered to the skin over each port. If four ports are used, the additional scattered radiation delivered to the various skin surfaces is appreciable. This is not important because of the recuperation of the skin during the twenty-four-hour interval, at which interval the successive treatments are given. Moreover, the additional radiation from the opposing portal is only 15 per cent, and this amount is well within the margin of safety.

The four-port method, while delivering more radiation to the axilla, necessitates care in the directing of the radiation beam, because it is difficult to place the patient in a convenient position for the superior port. We feel, however, that the four-port method has definite advantages over those previously used at the Memorial Hospital.

The multiple-port irradiation of the axilla is more applicable to divided dose technic than it is to the massive-dose method, because, in the former technic, the skin has four days to recuperate, while the tumor is being irradiated each day.

SUMMARY

1. An attempt is made to determine a method by which the greatest amount of radiation may be delivered to the center of the axilla, with minimum skin damage.

2. There are several combinations for the convergence of multiple radiation beams on the center of the axilla.

3. Measurements of many axillæ were made to determine the average distance to the center of the axilla from several possible ports. These distances are given.

4. The tissue dosage, in the center of the axilla from the several ports, is given, and the dosage from the combinations of converging beams totalled.

5. It is found that the four-port method is the most practical.

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A COMPARATIVE ANALYSIS BETWEEN THE PATHOGENESIS OF OSTEODYSTROPHIES AND BONE TUMORS[1]

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THE proper classification as well as the correct diagnosis and prognosis of tumors of the bone represent the most difficult chapter of oncology. Tumors of the bone may be indistinguishable morphologically and roentgenologically from inflammatory, metabolic, or endocrine diseases of the bone. Primary sarcoma, metastatic carcinoma, osteomyelitis, syphilis of the bone, and the various types of osteodystrophies may present pictures so similar that a differential diagnosis becomes impossible. Von Recklinghausen (1), in his classical study in 1891 on the pathology of the disease of the skeleton which bears his name, came to the conclusion that this disease presents close analogies with Paget's disease of the skeleton and osteomalacia on one hand, and with metastatic carcinoma of the skeleton on the other.

The reason for these complexities must be sought for in the structure and function of the normal bone. Bone tissue, though apparently inert and serving, with fibrous tissue, as the groundwork for the parenchymatous organs, is in reality endowed with finely designed functions. On one hand, it acts as a rigid protecting receptacle for the central nervous system and the bone marrow—a blood-forming organ. On the other hand, it acts as the rigid framework for the whole organism, supports and guides the nerve-muscle apparatus and the joints, and thus makes correct locomotion, the obtaining of food, and self-protection possible. These functions require truly mathematical precision. It is remarkable how well deformities caused by poorly set fractures or by diseases, like rickets, may be corrected both as regards the function and the shape of the bone. To understand this phenomenon, not only the ontology but the phylogeny of the vertebrates must be taken into consideration.

In view of these functional requirements, any insult which the bone receives from the outside or inside of the organism, any destruction of bone or loss of continuity of the bone tissue, is followed by a very active reparative or reactive process accompanied by new bone formation. The more efficient this reparative process, the more extensive the new bone formation (the osteoplasia), the more difficult is it to differentiate the underlying cause. The new osteoplasia dominates the picture.

These difficulties become particularly evident when the necessity arises to differentiate between the osteoplastic types of the osteodystrophies and the osteoplastic skeletal metastases in carcinoma. While the pathogenesis of the two conditions must be entirely different, the resultant condition is frequently identical.

The purest type of rapidly forming new osteoplasia after a loss of continuity is the formation of a callus in a traumatic fracture in the case of a normal individual. A comparative study of the healing of various types of abnormal fractures may help in the understanding of the mechanism of the various reactive processes of bone.

A serial roentgen study of a traumatic fracture of the humerus in a patient suffering from osteitis deformans (Paget's) has shown most unusual healing reactions. It seemed of value, in order to assist in the elucidation of the pathogenesis of bone tumors and oesteodystrophies, to report the case and compare the findings with the results of the previous roentgenologic and pathologic (2) studies of the early stages of metastatic carcinoma of the bone.

OSTEODYSTROPHIES

There is a group of diseases of nutrition and of the endocrine glands in which

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the symptom-complex is caused by the pathology of the skeleton, a group which may rightly be called osteodystrophies, since in the ultimate analysis these conditions in the skeleton are caused by abnormalities in the endocellular metabolism. The most common of this group are osteomalacia, osteitis fibrosa (von Recklinghausen), and osteitis deformans (Paget's), all characterized by a slowly progressing disturbance of the structure of all, or the major part, of the skeleton. A picture of complete destruction of the bone and replacement by soft tissue dominates in osteomalacia. Transformation of normal bone into fibrous calcified connective tissue, which replaces the compact and cancellous bone as well as the bone marrow, is characteristic of osteitis fibrosa and osteitis deformans.

Frequently, however, both processes are present side by side and it may be impossible to differentiate pathologically osteomalacia from osteitis fibrosa, and just as difficult to distinguish osteitis fibrosa from osteitis deformans. In a general way, the former is accompanied more frequently by formation of large cysts and so-called giant-cell tumors, and osteitis deformans by new bone formation, but both cyst formation and osteoplasia are present in the two diseases.

The etiology of the osteodystrophies is quite unknown. Lang (3), Jaffe (4) and others have succeeded recently in producing similar conditions in the bones of animals by removal of the parathyroids, thus producing experimental proof of the intimate relationship between abnormalities in endocrine functions and the disturbances in the skeleton. However, the nature of this relationship is not clear. The assumption that general acidity of the organism and lack of calcium in the circulation are followed by an absorption of the calcium from the skeleton is too crude a conception of endocellular metabolism and does not account for the occurrence of localized osteitis fibrosa or deformans in which many parts of the skeleton remain unaffected. In the case reported in this presentation the calcium content in the blood was normal. Moreover, the function of the parathyroids and the abnormalities of the calcium metabolism do not represent the only, or even the main, causes of either osteoporosis or osteoplasia.

In order to get a clearer insight into the causation of osteodystrophies it is necessary to understand the mechanism of the pathologic transformation of the skeleton—its pathogenesis.

The osteodystrophies are chronic conditions: they last for years and usually do not cause any general disturbances in the organism until after the pathologic process is completely established, and often not even then. Therefore, the pathologist or the radiologist rarely gets the opportunity to observe the mechanism of the formation of these abnormalities from the incipiency to the final development of the condition. The case presented here offered such an opportunity for the study of the early stages of formation of osteitis deformans.

CASE REPORT

J. A., male, 63 years old, came to the writer on March 9, 1932, with a history of having sustained, four days previously, a fracture of the left arm, caused by a fall on a slippery floor while dancing. The patient stated that, two years before, he had sustained a fracture of the left scapula. Otherwise he had no complaints and gave no history of any previous disease. He is active as a clerk in the Post Office Department.

Examination showed the fractured arm in a temporary splint and, on superficial inspection, no other abnormalities. A roentgenogram of the arm in the splint showed a fracture in the lower third of the humerus, while the head of the humerus and the scapula showed irregular areas of rarefaction interspersed with strands of new bone formation (Fig. 1). A provisional diagnosis of osteitis deformans was made. The temporary splint was removed and roentgenograms of the arm taken. At the lower third of the shaft of

Fig. 1 (*above*). Roentgenogram of the left arm in the provisonal splint. Shows osteitis of the head of humerus and scapula.

Fig. 2 (*below*). Roentgenogram of left humerus without splint. Shows the fracture and little abnormality in the bone.

the humerus there was noted a complete oblique fracture, with displacement of the

Fig. 3. Roentgenogram of left humerus with splint. Shows the improved position of the fragments.

lower end upward and forward and of the upper end downward and backward. Both the middle and lower thirds of the humerus showed little evidence of the osteitis noted in the head of the humerus (Fig. 2). In view of the diagnosis of osteitis deformans no attempt was made at complete reduction. A better apposition of the broken fragments was obtained and a plaster cast applied (Fig. 3).

Roentgenograms were taken of the left arm in the cast and also of the skull, pelvis, and both femora. The skull and pelvis showed advanced stages of osteitis deformans. The femora appeared thickened and bent, but otherwise showed an earlier stage of the disease (Figs. 4, 5, and 6).

A clinical examination of the patient was then made, showing, on inspection, dry skin, little subcutaneous fat, prominent subcutaneous arteries, and no other ab-

normalities. Lungs and heart showed no abnormality. Blood pressure was 130/70; pulse rate rapid and easily excitable (100 to 140 a minute), but there was no exophthalmos and no enlargement of the thyroid.

Fig. 4. Roentgenogram of the pelvis. Shows fully developed osteitis deformans.

Basal metabolism was plus 14. No abnormalities were found in the gastro-intestinal nor in the genito-urinary tracts. Wassermann test was negative.

Blood chemistry showed sugar 132 mgm., non-protein 30.2 mgm., uric acid 4.4 mgm., calcium 12 mgm. Blood morphology showed erythrocytes 4,550,000, leukocytes, 8,250, polymorphonuclears 77 per cent, lymphocytes 23 per cent, hemoglobin 96 per cent, color index 1.0. This clinical analysis showed no organic disease, with the possible exception of hyperthyroidism.

One week later a roentgenogram of the left humerus showed the fractured ends in the same position and no evidence of callus formation (Fig. 7).

Two weeks later a roentgenogram showed no change in the position of the fractured ends and a beginning of a callus formation. At the same time an area of osteoporosis appeared in the lower segment (Fig. 8).

Six weeks later, the area of osteoporosis had increased (Fig. 9).

Six months after the cast had been applied a roentgenogram showed an extensive callus, and both the callus itself and the shaft of the humerus above and below it showed an advanced state of osteitis deformans (Fig. 10). It is significant that during the same time the condition in both femora had not advanced. The cast has been removed and the result appears functionally perfect. The bone is solid, the arm is not foreshortened, and, notwithstanding the slight atrophy of the muscles, the limb functions normally.

At present the humerus and its callus present a perfect picture of osteitis deformans but the patient appears to have a normal arm clinically.

The most unusual phenomenon observed in the course of the healing of the traumatic fracture in this case, which distinguishes it both from the healing of a

Fig. 5. Roentgenogram of the skull. Shows fully developed osteitis deformans.

traumatic fracture of a normal individual and from the healing of a pathologic fracture within a malignant tumor of bone, is the following. A rigid and perfectly functioning callus was formed. At the same time, within the callus itself and in the shaft of the humerus both above and below the callus, were noted numerous areas of bone absorption (minute cysts). In other words, the callus formation was accompanied by progressive local development of osteitis deformans. A normal callus in a traumatic fracture of a normal individual shows only new bone formation and no absorption of the newly formed bone. Rarefaction of bone or cyst formation occurring in a traumatic fracture of a normal individual would indicate (Fig. 8) the formation of a sarcoma within the callus.

The development of a sarcoma within a callus is observed frequently, though it is usually impossible to ascertain whether or not a minute, indiscernible sarcoma was present when the fracture occurred.

A callus produced as a result of a pathologic fracture in skeletal metastasis of carcinoma may appear on superficial analysis similar to the callus described above in an individual suffering from osteitis deformans (Paget's). The important difference, however, between these two conditions is the following: The fracture healed perfectly (in the case described above) and at the same time the osteitis in the humerus progressed and became more advanced. A pathologic fracture, on the other hand, heals only when the growth of the carcinoma is arrested. A progress of the carcinoma is followed either by non-healing of the fracture or the occurrence of a new fracture. The mechanism of the healing of the fracture in the reported case of Paget's is, therefore, the best proof of the correctness of the diagnosis.

METASTATIC CARCINOMA OF THE BONE

In order to understand the basic difference in the pathogenesis of osteodystrophies and bone tumors it is essential to study the mechanism of the formation of the morphologic changes which take place in the bone in the course of the development of these two conditions. A generalized osteoplastic metastatic carcinomatosis of the skeleton, particularly if due to primary carcinoma of the prostate or thyroid, cannot be differentiated either microscopically or roentgenologically from osteitis deformans. A microscopic study of skeletal metastases of carcinoma may help in the understanding of the reason for this similarity.

The metastasis begins its development within the marrow, and, when the group of cancer cells is small, the surrounding bone marrow appears quite normal. Von Recklinghausen claims that the development of the metastasis is preceded by a hyperemia and hemostasis, due to obstruction of the capillaries by the tumor emboli. In the specimens studied by the

writer, hemorrhage and hyperemia were noted frequently around large tumor masses, but not around minute metastatic nodules. In the latter instance no morphologic abnormality could be found in the bone marrow.

the changes in the normal tissue surrounding the metastasis consist in destruction of the compact bone. These two separate conditions can be easily differentiated on the gross inspection of skeletal metastases. However, the microscopic study of the

Fig. 6. Roentgenogram of both femora. Shows an early stage of osteitis deformans.

As the tumor nodule increases in size it approaches and invades the compact osseous tissue or the compact osseous partitions of the cancellous bone. Then there begin to appear the characteristic changes in the bone tissue. There are two classes of skeletal metastases of carcinoma: osteoplastic, in which extensive new bone formation takes place around the metastatic tumor, and osteoporotic, in which

cases analyzed by the writer showed that both conditions were generally present side by side. The differences in the gross appearance are due to the fact that in one case esteosclerosis, or new bone formation, predominates, while in another osteoporosis, or the destruction of the old bone, is mainly in evidence.

The mechanism of bone destruction in metastasis of carcinoma differs from that

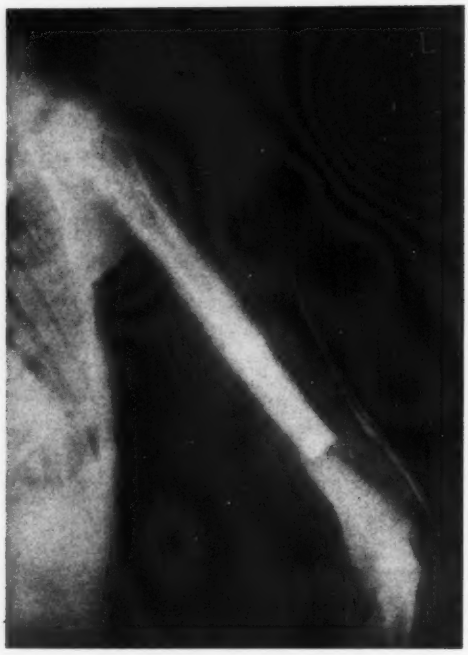

Fig. 7. Roentgenogram of left humerus one week later. No evidence of callus formation.

Fig. 8. Roentgenogram of left humerus two weeks later. Beginning of callus formation and beginning of osteoporosis.

observed in osteodystrophy. Von Recklinghausen first made the observation that the large polynuclear osteoclasts, which destroy the bone in osteoporosis, are very seldom found in the lacunæ of the bone surrounding a growing metastasis of carcinoma, a fact which has been confirmed by most of the subsequent investigators. In view of the absence of the large osteoclasts, von Recklinghausen presumed that a softening takes place in this bone, due to the removal of the inorganic salts and a subsequent absorption of the tissues without the aid of any cells, a condition similar to the one found in osteomalacia. Apolant (5), Erbsloeh (6), and Askanazy (7) are also of the opinion that osteoporosis in skeletal carcinoma may take place without the aid of special cells. On the other hand, Goetsch (8) believes that the cancer cells frequently found close to the walls of the lacunæ are special osteoclasts derived from the cancer stroma. In the specimens studied by the writer, both cancer cells and the small connective tissue stroma cells were found in immediate apposition to the walls of the lacunæ. The cancer cells were so frequently the only cellular elements within the lacunæ of the bone that it seems feasible to maintain that cancer cells may act as direct osteoclasts. The impression gained by the writer is that the small stroma cells only subsequently invade between the bone and the cancer cells. However, even if it be admitted that the stroma cells may act as osteoclasts, it is apparent that the tumor itself, by the aid of its formed elements, may destroy the bone, and then grow by occupying the space so formed.

The mechanism of the new bone formation as observed by the writer is as follows: At first, collagen fibrils are formed in abundance from the old bone. These fibrils gradually unite in thick bundles and subsequently form new bone tissue. The latter is clearly formed from the constituent parts of the old bone. On the other hand, as stated above, the writer did not observe any hyperemia, inflammation, or any other abnormality of the

Fig. 9. Roentgenogram of left humerus six weeks later. Increase of osteoporosis.

Fig. 10. Roentgenogram of left humerus six months later. Both the callus and the rest of the humerus show extensive osteitis deformans.

bone marrow at the beginning of the development of the metastasis. Furthermore, necrosis of the bone was not found in any of the specimens examined. It must be concluded that some unknown factor derived from the cancer cells acts on the old bone tissue and stimulates its proliferation.

Thus two processes always take place side by side in skeletal metastases. On the one hand, the tumor destroys the normal bone tissue; on the other hand, the remaining osseous tissue proliferates and creates new bone, the latter most probably being an attempt at self-defense. In the microscopic field in which this osteoplasia is shown there is frequently no evidence of any cancer cells and the microscopic picture cannot be differentiated from osteitis deformans (Fig. 10).

SUMMARY AND CONCLUSIONS

As was stated above, osteitis fibrosa and deformans appear to be morphologically and roentgenologically similar to osteoplastic metastatic carcinoma of the skeleton. There must also be, therefore, some similarity in the mechanism of the formation of the two conditions.

Osteitis fibrosa and osteitis deformans are comparatively rare conditions, the same being true of skeletal metastasis in carcinoma. Only 2.5 per cent of all cases of carcinoma of the stomach and 3 per cent of all cases of carcinoma of the uterus show metastases in the bones. It is significant that the types of carcinoma which most frequently develop metastases in the bones are carcinoma of the breast, of the prostate, and of the thyroid, *i.e.*, organs with active endocellular metabolism and endocrine functions. Moreover, even within these groups may be observed remarkable differences in development. In carcinoma of the prostate, the greatest number show extensive osteoplasia and the patients may continue to live even for years, with a well functioning skeleton. In carcinoma of the thyroid, the predomi-

nance of osteoplasia or osteoporosis is encountered with about equal frequency. On the other hand, in carcinoma of the breast, cases with osteoporosis are more frequently observed, and even a beginning of osteoplasia soon changes into osteoporosis.

In order to obtain a clearer conception of the relationship of these two phases in the development of skeletal metastases, as well as of osteodystrophies, it is necessary to analyze them separately.

The destruction of the normal bone tissue (osteoporosis) in skeletal metastasis is a purely local process and, as stated above, must be a direct function of the group of cancer cells transported to the bone. This function is most probably chemical, in accordance with von Recklinghausen's conception, and the resultant change in the bone, as he thought, is analogous to the condition found in osteomalacia. Probably not all types of cancer cells possess this capacity and many emboli of cancer cells which enter the bone marrow do not destroy the bone but are themselves destroyed by the normal tissue of the bone. The difference between the osteoporosis in carcinoma and in osteodystrophy consists in the fact that in the latter condition the cells which act on the bone do it at a distance and may represent the function of the parathyroids or other endocrine glands.

The new bone formation (osteoplasia) is undoubtedly, as stated above, an attempt at self-defense, a reactive or reparative process, and the mechanism of its formation is identical in all types of bone tumors or osteodystrophies.

The reason for the prominence of osteoplasia in some forms of osteodystrophies and tumors of the bone and its absence in others must be looked for in the differences of the function of the endocellular metabolism, whether it concerns endocrine action, nutritional deficiency, or local action of cancer cells. One type of cancer cells or of endocrine organs may predominate in its destruction of the bone over the reparative power of the latter, while in other types of cells the reparative function of the bone tissue predominates. It is interesting to note in this connection that, in a general way, osteoporosis (rachitic, carcinoma of the breast) prevails in the young and osteoplasia (Paget's disease, carcinoma of the prostate) predominates in old age. This coincides with the fact that, during senescence, many types of parenchymatous tissues are replaced by fibrous connective tissue. Scirrhous carcinoma, in which the fibrous stroma predominates, is also a disease of old age.

A fully developed generalized case of Paget's is usually easy to diagnose. However, there are many cases reported without any pathology in the skull or involving only a few bones and even only one bone (9). A final diagnosis of Paget's should not be made until the possibility of primary malignancy elsewhere is excluded. In the case reported in this paper the mechanism of the healing of the traumatic fracture established the diagnosis of Paget's, though the patient did not present a classical picture of the disease.

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ROENTGEN TREATMENT OF HYPERTHYROIDISM[1]

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From the Radiological Clinic of Drs. Groover, Christie, and Merritt

IN 1929 we reviewed all of our cases of hyperthyroidism, covering the period from 1917 to 1927, inclusive, and published a statistical analysis of 305 cases showing the results of treatment by roentgen irradiation (1). We will in this paper show the results of treatment of 252 additional cases, covering the period from 1928 to 1931, inclusive. Some of the statistical details embodied in the previous publication will be omitted from this report in order that other aspects of the subject may be more fully discussed.

It is our belief that statistics, as usually compiled for evaluating remedial measures in disease, are often accorded a degree of importance which they do not merit. Certainly this is true if mere weight of numbers is given primary consideration. Particularly in a disease such as hyperthyroidism in which there are so many collateral and complicating factors, both psychic and somatic, a mere tabulation of results following this or that method of treatment necessarily gives but an imperfect idea of the individual case. In one case an associated vascular hypertension or myocardial disease may render the interpretation of results exceedingly perplexing, and in another extrinsic circumstances such as the economic status of the patient or the personality and resourcefulness of the physician may be factors which determine success or failure of treatment. A careful analysis of fifty unselected cases, therefore, would be more illuminating than the compilation of five thousand cases which did not take these collateral factors into account.

Nevertheless, the latter method of approach has its value, and if it does nothing more, it gives some indication of the popularity of given remedial measures in particular communities, and affords a means of comparing the results of one method of treatment with another. Although it has been known for many years that irradiation is a comparatively satisfactory method of treating hyperthyroidism it is only recently that sufficient data in comparable form have been accumulated to parallel that relating to its surgical treatment.

There is far more to the treatment of hyperthyroidism than either irradiation or surgery connotes. Its successful management involves the management of a human being and not merely the treatment of a disease by a rule-of-thumb technic. Unless the radiologist is prepared to assume, and, in fact, does assume, that responsibility, he will have more than his share of unsatisfactory results. The fact that the radiologist has to a large extent been regarded as a dispenser of a remedy rather than as a clinician and consultant has delayed deserved recognition of irradiation as an effective method of treatment.

We have assumed such responsibilities in our own work for many years with, in the main, harmonious co-operation of internists who refer the majority of our cases to us. We record our own histories, make our own examinations, do our own basal metabolisms, and either have full responsibility for the general management of the case or share in it with the referring physician. Doubtless other radiologists who treat a considerable number of cases of hyperthyroidism pursue a similar policy, and we would not consider it worthy of mention but for the gratuitous assumption on the part of critics of radiological statistics that the radiologist does not do everything that the goiter surgeon does to make his statistics equally reliable. Formerly the attack on radiotherapy as a means of treating hyperthyroidism centered on the *absence* of statistics as to its value. Now

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

that statistics are rapidly accumulating the attack has shifted to their comparable reliability and to the competency of the radiologist to deal with the disease.

In a typical form hyperthyroidism presents but few difficulties in diagnosis, but particularly in view of the relative harmlessness of irradiating the thyroid many patients are being referred to the radiologist for therapy in which the problem of incriminating or absolving the thyroid presents many difficulties. Many such cases require prolonged clinical observation and repeated basal metabolic determinations. Without such critical study the statistics relating to hyperthyroidism will include many cases that do not properly belong there. Ten per cent of the cases coming to us with a diagnosis of hyperthyroidism fall in that group. The majority are made up of psycho-neurotics, constitutional inferiors, and the vascular hypertensives. When patients of these groups present themselves with a report of elevated metabolism, and particularly if there should be some thyroid enlargement, an expenditure of much effort is required to properly elucidate them, and in some the rôle of the thyroid may remain permanently doubtful. It is unfortunate that the fallibility of basal metabolic determinations is not sufficiently well recognized generally. If they do not harmonize with the clinical evidence any doubt as to the possibility of thyroid dysfunction should be resolved in favor of the clinical evidence until every one of the many possible sources of error in the metabolic determinations have been repeatedly checked and conclusively eliminated.

There has been very little variation in our method of treating hyperthyroidism during the past ten years.

At our first interview with a patient we tell him what we expect him to do and what we expect to accomplish. Such patients usually have many questions to ask and time should be taken to answer them frankly and in considerable detail. The principles of treatment and the results to be expected have become so thoroughly established that there is no longer any justification for indefinite or evasive replies. In our earlier experience, many patients, after one or two treatments by irradiation, would abandon it in favor of surgery, but as confidence in the former has become more firmly grounded not only in our own minds but in the minds of our medical confrères and the laity such occurrences have become increasingly rare.

The general management of patients with hyperthyroidism is so well outlined in most of the standard text-books on the practice of medicine that it would seem unnecessary to stress it here but for the fact that the specialist is prone to underestimate its importance. Nothing that the radiotherapist or surgeon is able to accomplish in this disease obviates the necessity for physical rest, either complete or modified, as the degree of toxicity may indicate. For patients exhibiting marked toxicity, bed rest is insisted upon. They almost invariably rebel at the suggestion, but if the reasons for it are patiently and sympathetically explained, their wholehearted co-operation (which is considered highly important) can usually be obtained. More than six weeks of complete rest is seldom required: even if a longer period is indicated, it is often desirable to permit sufficient liberty to maintain morale. For the milder cases, modified rest is prescribed. By a careful study of the occupational, social, and recreational habits of such patients their physical activities can usually be reduced at least 25 per cent without requiring undue sacrifices on their part. It is of considerable importance that the rest requirements of the individual patients be appraised as accurately as possible at the beginning of their treatment, as they are peculiarly susceptible to suggestions that seem adverse to their favorable progress, and it causes an unfavorable reaction if it becomes necessary to shift from partial to complete rest, especially if such a contingency has not been anticipated. Mental tranquility is no less important than physical rest. These patients need to be inspired with hope and confidence

in a successful issue, and this is always attempted, but never to the extent of overstepping the bounds of sincerity and perfect frankness. Mental conflicts should be corrected, fears allayed, and morale maintained.

Supervision as to food and water intake should not be neglected. Ordinarily medication is of minor importance. Sometimes sedatives are helpful, and, to meet special indications, such as cardiac decompensation, appropriate remedies are, of course, used. The use of iodine, with due regard to its limitations, is often helpful: whereas the surgeon uses it to prepare the patient for operation, the radiologist can at times use it advantageously until irradiation has time to become effective. Unfortunately, its use all too frequently leads to delay in instituting curative measures, and, by masking the symptoms of the disease, is apt to mislead the radiologist as to the amount of irradiation necessary to effect a permanent cure.

Foci of infection should be routinely sought for and eliminated as far as possible, due regard being given to the hazard that any operative procedure might entail. We have on a number of occasions seen rebellious cases proceed to prompt recovery after the removal of infected teeth or tonsils, and have reason to believe that some unsatisfactory results are traceable to irremediable focal infections.

Undoubtedly hyperthyroidism is successfully treated by irradiation with rather widely varying technics. It is our practice to administer treatments at intervals of three weeks. Three areas are exposed, one over each side of the neck and one over the upper sternal region. The size of the portal is varied to conform to the anatomical structure, but we consider it important to irradiate the entire thyroid and thymic areas and the size of each portal is seldom less than 8×12 centimeters. The marking off of the areas, the positioning of the patient, and the adjustment of the tube should be closely supervised by the radiologist and not left entirely to the discretion and judgment of a technician. The physical factors as to dosage are 5 milliamperes of current, 140 K.V., 10-inch focal distance, and 5 mm. aluminum filter—with these factors the administration of 200 r through each portal is regarded as entirely safe and is the dose routinely employed. We have never seen any immediate or remote deleterious effects on the skin or larynx when the roentgenologist adheres to it. No doubt favorable effects are manifested somewhat sooner and fewer treatments are required when larger doses are employed, and in selected cases we believe this method is justifiable, but, on the whole, the potential disadvantages of larger doses outweigh their advantages. Regardless of the ultimate result, we find that 38.5 per cent of this series of cases has been given six treatments or less; 39.7 per cent, more than six but less than ten, and 21.8 per cent, more than ten. The number of treatments which may be required in the individual case cannot be foretold, and any assurances given patients in that regard should be in terms of the average. Highly toxic cases may get well and remain well after three or four treatments, whereas mild cases may require three or four times as many. Indeed, it is our impression that the more the individual case deviates from the perfectly typical, full blown thyrotoxic syndrome, the more troublesome it is to treat. We have not set an arbitrary limit to the number of treatments to be given patients, but judge each on its individual merits. Improvement is usually manifested within two months from the beginning of treatment and is progressive.

We do not know of any contra-indications to the treatment of hyperthyroidism by irradiation. It is conceivable that in rare instances pressure symptoms may constitute an emergency, and, under certain conditions, particularly with respect to availability, treatment by irradiation may be less practical than surgery: under such circumstances the latter is given preference. There are no logical reasons for combining the two methods except to the extent that where one has failed to cure, the other may be employed. Malignancy

has not supervened in any of the 557 cases treated by us, covering a period of 16 years, nor do we know of such occurrence in the practice of other radiologists. It is our belief that malignancy of the thyroid, particularly clinical malignancy, is a rare disease, and that the suggestion of operating on all adenomatous goiters with a view to preventing it is wholly misconceived. In a large series of cases at the Mayo Clinic (2) the ratio of malignant tumors of the thyroid gland to all simple goiters (colloid and adenomatous) was 1 to 36.7 (2.7 per cent). It is admitted that there are no data available as to the incidence of both conditions, and it is pointed out that most persons with carcinoma of the thyroid eventually seek medical advice for it, whereas many with nodular goiter do not. In 65 per cent of the cases of the Mayo Clinic series the diagnosis rested solely on the microscopic findings which, at least from a practical standpoint, are not necessarily final or conclusive. It is not altogether fanciful to assume that cells undistinguishable from malignant tumor cells might be uncovered in every human being past middle life, provided every cell in the body could be inspected under the microscope. It is highly probable that even now the aggregate number of deaths from surgical operations on the thyroid far exceed the number of deaths from cancer of the thyroid, and, if that be true, the recommendation of surgery as a preventive measure for the latter would appear to be founded on wholly fallacious reasoning. Other objections that have been raised to the irradiation therapy of toxic goiter are equally chimerical or inconsequential. The only pertinent considerations relate to its effectiveness and comparable safety in curing the disease.

Of the 252 cases comprising the present series, 55 (21.82 per cent) were classified as mild; 138 (54.76 per cent) as moderate, and 59 (23.42 per cent) as severe. Of the series, 202 (80.15 per cent) were cured; 39 (15.47 per cent) were improved, and 11 (4.38 per cent) were unimproved. Recurrence took place in 3 (1.19 per cent). Of the series, 16 (6.35 per cent) had previously been operated on without cure: of these, 12 (75 per cent) were cured, 3 (18.75 per cent) improved, and 1 (6.25 per cent) unimproved. Seven patients (2.38 per cent) were operated on after irradiation therapy had failed to effect a cure, the results in these cases being unknown. Five cases (2 per cent) developed hypothyroidism after irradiation: there were no other sequelæ. The average gain in weight for all patients of the series was 13.3 pounds.

Pursuing our usual policy with respect to follow-up of cases of hyperthyroidism, most of those in this series and many in our previous series are still kept under periodic observation. We find little difficulty in having such patients return for periodic check-up, provided they are given definite appointments, personal attention, and are not charged for the service.

Our own results are about on a par with those of other radiologists, particularly those who have treated a considerable number of cases. Menville (3) collected over ten thousand cases treated by radiologists scattered throughout the country, which show a remarkable uniformity in the results obtained.

There are now abundant data, equally comprehensive in detail and reliable as to pertinent facts, for comparing the results of irradiation therapy with those of surgery. Despite all that has been said as to their respective merits and demerits, the only vital consideration as to choice between them lies in the fact that the former is unattended by mortality, whereas the latter is attended by a definite mortality. This percentage of mortality, though low in the hands of the experienced goiter surgeon, is undoubtedly considerable in the hands of the average general surgeon. Both groups have probably about reached the limits of their efficiency and it must be admitted that both fall short of an ideal method of treatment for this disease.

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THE "RISE IN VOLTAGE" EFFECT OF THERAPY X-RAY TUBES[1]

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IN the past, one of the chief worries of the roentgenologist practising therapy has been the uncertain and usually short life of the deep therapy x-ray tube. These tubes were usually operated under the published ratings, yet a life of 200 hours was considered reasonably good. The tube usually failed by electrical puncture in some portion of the glass envelope. The introduction of heavy-walled pyrex bulbs and tubing in the manufacture of these tubes largely eliminated this difficulty and added greatly to the tube life and steadiness of operation.

It has been noted, however, by certain users of these new tubes that the voltage across the tube rises as the tube heats up, if the milliamperes are held constant. This voltage rise is usually accompanied by a corresponding, though smaller, change in the x-ray output.

The wide variations in this effect brought about by the different types of tubes and machines make our measurements to date too limited for anything but a qualitative report on the magnitude of this effect. The underlying cause, however, has been investigated more fully, and it is this phase of it which will be considered now in detail.

As a first step in this investigation, the variation in voltage and x-ray output, with time, was measured for a heavy-walled deep therapy tube operated on a full wave mechanically rectified unit. The current through the tube was held constant. The result is shown in Figure 1 (Curve *A*). The variation in output with this mechanically rectified unit was irregular but quite small, and was not plotted. The work was then continued on a half wave valve rectified machine, with the rather striking results shown in Figure 1 (Curves *B* and *C*), and Figure 2. The equilibrium time for Curves *B* and *C*, Figure 1, is reduced to 5 and 12 minutes, respectively, at 6 milliamperes. As will be pointed out later, these curves cannot be taken as typical of these types of machines since the characteristics of the particular transformers and controls are the governing factors. The seriousness of this situation lies in the possibility of the users of these tubes either measuring the output or voltage before equilibrium conditions are reached. With certain machines, if the initial voltage is 200 K.V., the equilibrium peak voltage could be as high as 250 K.V., and the x-ray output increased 25 per cent. This would result in an overdose to the patient and an overload for the tube.

It was found necessary to wait between 15 and 30 minutes after turning off the power before the voltage would start at its lowest point: this gave us an opportunity to determine whether the time effect was in the tube or transformer. By connecting two tubes in parallel across the high voltage terminals with independent filament controls, first operating one tube and then the other, it was possible to determine that the time element depended on the tube alone. Yet the effect was not independent of the generator, since the same tube showed a different rise on a different generator. It was suspected that there must be some change in the tube characteristics on heating, which, in turn, influenced the wave form of the high voltage generator.

This wave form change was investigated by means of a cathode-ray oscillograph with connections as shown in Figure 3. Figure 4 shows the type of current and voltage waves obtained by this method for cold and hot tubes.

[1] Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

The first striking fact is that the voltage never drops to zero though this was a half wave valve machine with the only capacity that of the transformers. This is not quite so surprising, however, if we examine the current wave and note that for a goodly part of the cycle no current is flowing, which means that an extremely small capacity would be sufficient to maintain the voltage. It will be noticed that the voltage rises higher and falls lower on the hot tube. The current, on the other hand, has a much higher peak value for the cold tube.

Granting some cause for this high peak current for the moment, the explanation becomes simple. The load on the machine increases at this point of the cycle, which, due to the internal resistance of the transformers and controls, causes a lowering of the peak voltage. Now as the tube warms up the peak current falls off (the average current as read by the milliammeter being held constant), which relieves the load on the transformer at this point, with a consequent rise in peak voltage.

In an effort to find an explanation for

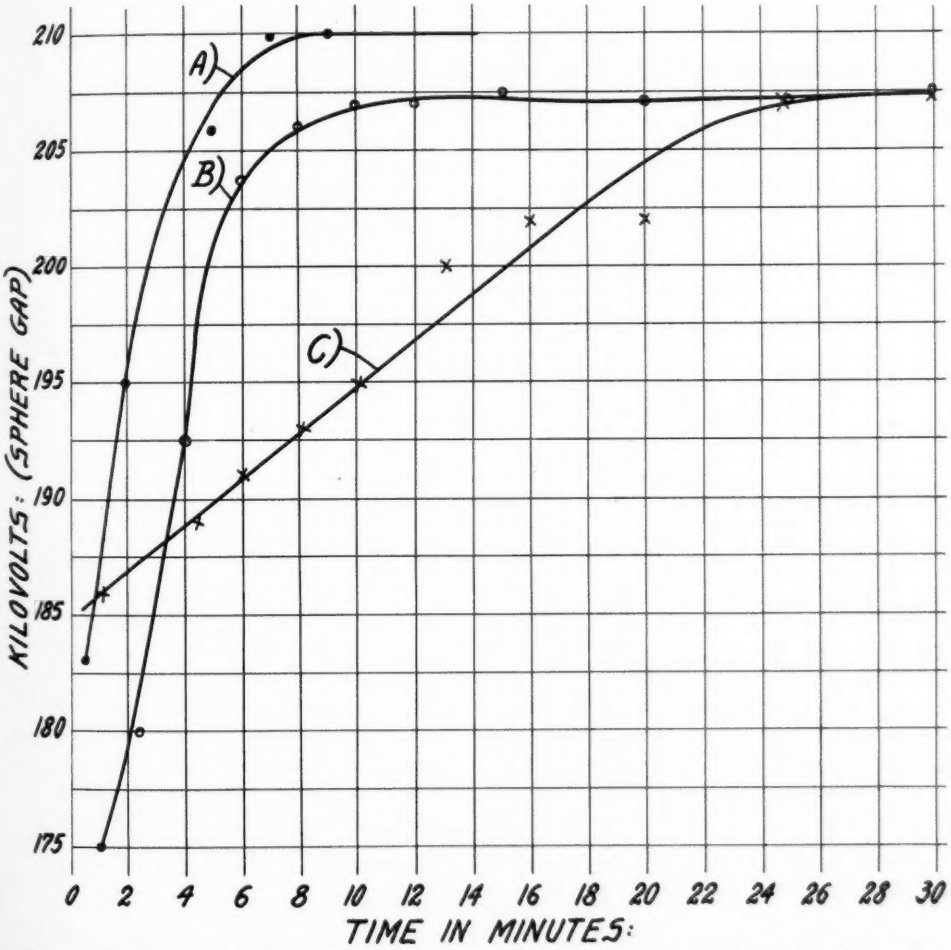

Fig. 1. Curves showing voltage rise for: (*A*), Pyrex therapy tube operated on full wave mechanically rectified machine at 8 Ma.; (*B*), and (*C*), therapy tubes operated on half wave valve rectified machine at 4 Ma.; (*B*), wall thickness $^{5}/_{16}$ inch; (*C*), wall thickness $^{1}/_{4}$ inch.

this change in peak current value a special tube was used. Three equally spaced conducting rings were painted on the inside of the bulb, having their centers on the tube axis. These were connected through the glass to corresponding rings

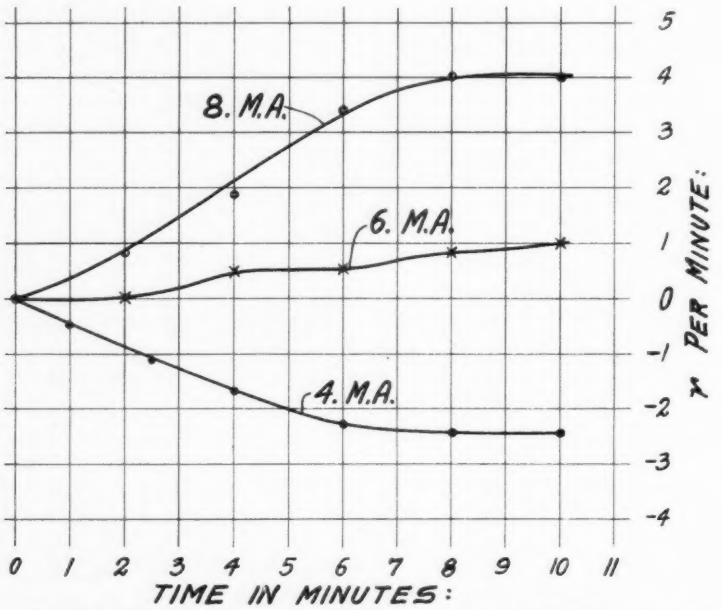

Fig. 2. Curves showing change in therapy tube output with time for three current values. Half wave valve rectified.

on the outside. Between the central inner ring and the lead-in wire there was a gap of about an inch where the conducting material had been removed. When this tube is operated cold, even as low as 100 K.V., there is violent sparking over this gap, showing a large potential difference between the inner and outer surfaces of the bulb. When the bulb becomes hot this sparking stops and the tube operates normally—the glass of the bulb has become conducting. When these seal-in wires are connected through a milliammeter to ground, as much as 1.5 milliamperes will flow with a tube current of 8 milliamperes. This current flow is in the proper direction for electron flow to ground, and is due to scattered electrons from the target, some of which have velocities close to that of the primary beam.

Now referring to the curves showing the voltage and current waves (Fig. 4), the explanation of the whole phenomenon becomes as follows.

When the pyrex glass is cold it is a good insulator; thus the scattered electrons from the anode charge the inner surface of the bulb to a potential equal to that of the cathode at the peak of the voltage wave. As the tube voltage falls during the next part of the sine wave, this negative charge remains and acts like a grid, preventing electrons from leaving the filament. When the tube is hot the glass becomes conducting, thus allowing the charge to dissipate through the bulb walls, which, in turn, permits more current to flow from the filament at the lower voltage portions of the sine wave. The filament temperature must then be lowered to maintain the 8 ma. average current as shown by the milliammeter.

The filament temperature, however, de-

termines the peak milliamperage and when this is lowered there is a corresponding drop in the load on the transformer, resulting in a peak voltage rise. It is interesting to note, in Figure 4, that, with a heavy-walled therapy tube operating at 200 K.V. and 10 ma., the tube is passing at the peak of the voltage wave 44.5 ma., when cold, and 26.6 ma., when hot.

The effect of these wave form changes on the x-ray output is not so large as one might expect since there are two factors involved which tend to neutralize one another. First, with a cold tube the peak voltage is low but a large part of the current flows through the tube at this portion of the voltage wave: second, when the tube warms up the maximum voltage increases but a smaller percentage of the current is flowing at this time.

Thus the change in quantity and quality of the x-ray output is intimately tied up with the generating equipment. On some machines the output will go up, and on others down, as the tube heats up. Fortunately, in most cases the change in output is not so great as would be expected by the change in voltage.

An interesting exception to this rule is an ideally built pulsating machine in which there is no appreciable energy loss in the controls or transformer. This

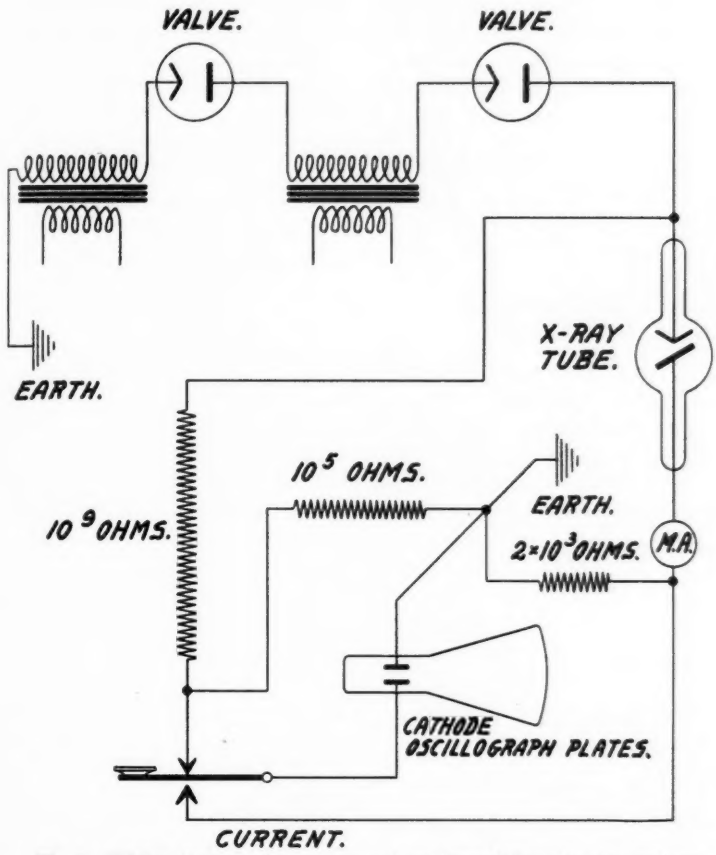

Fig. 3. Wiring diagram of generator and oscillograph for obtaining voltage and current waves.

machine shows no voltage change but a lowering of some 25 per cent in x-ray output, with the establishment of equilibrium conditions at 200 K.V. and 8 ma. The oscillograph also explains this as being due to a broadening of the current wave, with a corresponding fall in the current flowing at the crest of the voltage wave.

In practice there are three ways of overcoming these variations in voltage and tube output:

I. By the use of a constant potential machine;
II. By the operation of the tube in a manner to keep the glass cool;
III. By allowing sufficient time for the tube to reach temperature equilibrium.

I. The constant potential machine, except for the expense involved, offers an ideal solution for the problem. The output and voltage are the same for hot and cold tubes. There are no wave form troubles with which to bother. It gives a real meaning to voltages as measured by a sphere gap or electrostatic voltmeter. It is by far the most efficient type of x-ray generator, and, in spite of some opinion to the contrary, is probably the easiest on the tube.

II. If the pyrex glass is maintained at a temperature below 100° C., it retains its insulating properties and the output and voltage will remain constant.

TABLE I.—SHOWING THE APPROXIMATE OUTPUT IN "r PER MINUTE" FOR THREE COMMONLY USED TYPES OF MACHINES: 200 K.V., 8 MA., 50 CM. DISTANCE, 0.5 MM. CU PLUS 2 MM. AL FILTER

Constant potential	Full wave mechanically rectified	Half wave valve rectified
34.0	22.5	17.0

III. In practice, at the present time, a large majority of the outfits in use are half or full wave rectified either valve or mechanical. With these, the simplest solution is to measure the time required for the establishment of equilibrium conditions under which the work is being conducted and to wait this interval before measuring

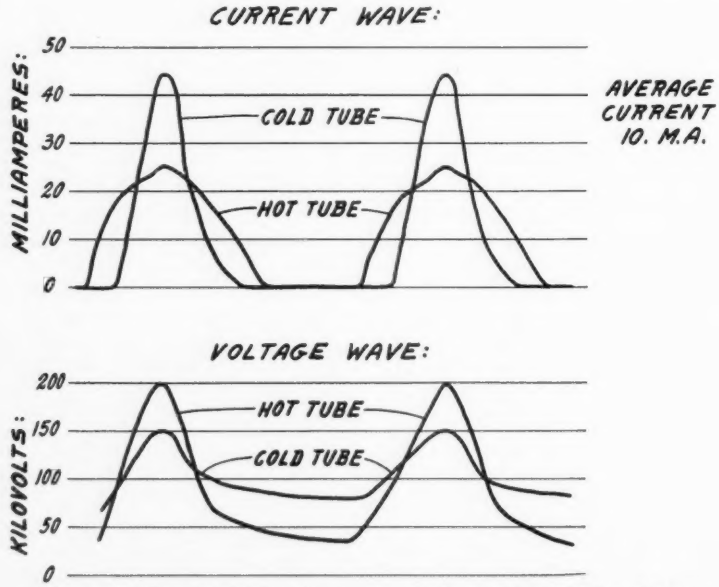

Fig. 4. Oscillograph picture of current and voltage characteristics of heavy wall deep therapy tube on 60 ~ half wave valve rectified machine.

either voltage or output. At 8 ma., the longest equilibrium time was about six minutes, whereas at 4 ma. it varied between eight and twenty minutes, depending largely on the tube wall thickness.

Since the preparation of this manuscript our attention has been called to an abstract which appeared in the program of the American Roentgen Ray Society at their meeting, Sept. 27 to 30, 1932, at Detroit, Michigan, entitled "The Behavior of Different Types of Deep Therapy X-ray Tubes on Different Types of Generators," by Lauriston S. Taylor, Washington, D. C. This abstract considers certain phases of the problem dealt with here.

DISCUSSION

DR. A. MUTSCHELLER (New York City): Dr. Slack's paper touches on a subject upon which I have been making observations for a long time. In calibrating many different types and makes of deep therapy apparatus, I have frequently found that there are changes in the radiation intensity during the first few minutes of operation of the tube and the machine. While keeping in mind all the data that might have a bearing on this subject, I came to the conclusion that there are three factors involved as being responsible for the changing output—one being the tube, and the other two being connected with the high voltage generating equipment.

In my laboratory, I had an opportunity fully to investigate the characteristics of tubes with constant potential current, and I found that some tubes do have definite characteristics, or do undergo definite changes during operation as time goes on. These are, of course, typical tube changes, namely, a gradual decrease of milliamperage due to adjustments between the heated parts of the tube, and the remaining gas pressure. However, with careful and prolonged operation, these conditions usually clear up in a manner which is generally well known as seasoning of x-ray tubes. Therefore, these changes are distinct and they are easily recognized as against the changes that are dependent upon the machine.

With some types of machines, especially those in which the transformer iron is very highly saturated, I found that, ordinarily, it takes from seven to ten minutes for the radiation output to become constant. Before that time, the output is lower (I should say, on an average, about 20 per cent) than the final equilibrium radiation intensity, and it increases gradually. Very often the voltage, as indicated by the sphere gap measurement, also increases. These, of course, are observations while the heating current or the milliamperage of the tube are kept constant and while the control remains unchanged.

Another type of apparatus which I tested, and which produced constant potential without any superposed high frequency or unduly large ripples, brings the tube to equilibrium in a very short time and, ordinarily, there are no changes except possibly such as are due to heating of resistances when they are present. Therefore, for the proper operation of x-ray tubes with constant potential, there should be used a minimum of ballast resistance so that the condensers are always fully charged to normal voltage. If a large amount of ballast resistance is used, then we have changes, caused by heating of resistances, or of the type reported with one of the previously mentioned types of machines.

I reached the conclusion that radiation changes during the first minutes of tube operation are due, first, to seasoning of the tube; second, to magnetically oversaturated iron cores which take about eight minutes to come to an equilibrium, and third, through heating of regulating resistances, if such are present.

HIP JOINT CHANGES IN HEMOPHILIA[1]

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WHILE there are many cases of hemophilia in which joint disturbance is one of the outstanding symptoms of the disease, there are other cases in which the patient may remain free from joint symptoms throughout his lifetime. Schloessman (1) estimates that one-third of all hemophiliacs are free from joint symptoms, whether sporadic cases be examined or whether the members of a single family of males be investigated.

The usual onset of symptoms is in the first or second year, following the small injuries to which the joints are normally subjected. Many cases, however, appear to have their onset between the ages of 9 and 13 years, just before adolescence. Apparently hemorrhages in the region of the joints, which are responsible for the hemophilic arthropathy, may, in some cases, occur spontaneously. The knee joint is by far the most frequently involved, followed in the order of their frequency by the elbow, ankle, and hip joints. The hands and shoulder joints are rarely involved. In isolated instances, the fingers or the temporomandibular joints may be affected.

In the German literature, joint changes in some cases have been followed for fourteen or fifteen years. In one case, at the age of two, the pain and heat appeared spontaneously, producing a swelling in the sternoclavicular and ankle joints. From that time on to the age of 10, there was pain and limitation of motion in the various joints of the arms and legs, usually lasting for from six to eight days. As a result of these, the knee, elbow, ankle, and hip joints became affected. Most of the attacks occurred without noticeable trauma. In one instance, there was a large hemorrhage into the left knee joint, resulting in flexion and limitation of motion which confined the patient to bed. At the age of 15, the patient had marked enlargement of the left elbow and marked contraction of both knees, which were flexed to about an angle of 45° on the left, and 90° on the right. Both knee joints were thickened and painful. With the exception of the elbow, the other joints remained free from permanent changes. At the age of 30, there were permanent contractures about the left knee so that the patient was compelled to walk on crutches.

In the first or second year of the joint disturbance, the roentgenogram is usually negative. Later, when limitation of motion occurs in the joint, the roentgenogram will show atrophy of the neighboring bones. This is followed by destruction of the joint surfaces, with peri-articular irregularities, resembling arthritis deformans. The joint cartilage disappears and the joint surfaces approach each other. Synostosis may occur. Accompanying these intra-articular changes, there are usually peri-articular manifestations. The earliest of these may be a hazy shadow in the soft parts, caused by peri-articular hemorrhage, which later may be followed by calcification and ossification. The bones about the joints become enlarged and broadened across their articular surfaces.

In the early stages, the roentgenologic changes may resemble those of tuberculosis, osteochondritis, or coxæ juvenilis; later they simulate osteitis deformans. The family history and the patient's past history of bleeding are the most important factors in the differential diagnosis. Another point of differentiation is the short duration of the pain, which subsides after from four to six days in the hemophilic joint. In the other conditions mentioned, the pain is more chronic, tending to become constant. It is only when there are marked peri-articular shadows, with signs of ossification about the joint, that the roentgenogram may be characteristic.

[1] Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

Key (2) is of the opinion that bony ankylosis in hemophilic arthritis does not occur. He states that the changes in the cartilage which are characteristic of a hemophilic joint have a map-like appearance, due to cartilage destruction, and that the characteristic change in the bone is the formation of cavities in the intra-articular portion. He believes that bone destruction does not occur until late in the disease, and that at some stage of the disease, the bone becomes markedly atrophic as a result of disuse. The areas of bone destruction are frequently so extensive that they are clearly visible in the roentgenogram.

Marked hemarthrosis, due to bleeding within or about the joints from the synovial membrane or peri-articular structures, is most common in the region of the knee or elbow. Roentgenographically, changes about the hip joints of hemophiliacs, however, are rare. Löhr (3) reported two patients of pre-adolescent age who showed typical signs of osteochondritis deformans juvenilis. Reviewing the literature in regard to these changes in the region of the hip joint, he found that the bleeding might be intra- or extra-articular, and that bleeding before puberty usually gave rise to osteochondritis, whereas, at a later age, coxa valga or cyst-like formation in the neck of the femur might develop.

Recently a case of hemophilia (4) was treated by intramuscular injection with ovarian extract, with excellent result. Birch (5) is credited with the discovery that a hormonal disturbance exists in hemophilia which is temporarily relieved by parenteral administration of ovarian substances. The potential value to surgery of the clinical application of Birch's discovery is obvious.

I will report briefly two cases, one a white male, aged 19, with extra-articular changes about the hip joint, due to hemophilia. This will be contrasted with a similar case in a younger patient in whom the changes were intra-articular, emphasizing the point that the age has a definite bearing on the pathology produced.

CASE REPORTS

Case 1. White, male, aged 19 years. The patient complained of pain in the right hip joint, present for about two weeks before this examination, and pain in the left hip joint which had been present for about two years, not preceded by a history of trauma. There was no relative history obtainable in regard to the present illness. The patient has two sisters living and well, who are not hemophiliacs. He has four brothers living who are known to be hemophiliacs, as is the patient. One brother, aged 7 years, died from intracranial hemorrhage 10 days after an injury to the head. Horse serum was used, and also his father's blood intramuscularly, but without benefit. As a young man, the father suffered from frequent nose bleeding, but there had been no hemorrhage in adult life. There was no history of hemophilia on the paternal side. The mother is not a hemophiliac, and there are no hemophiliacs on the maternal side.

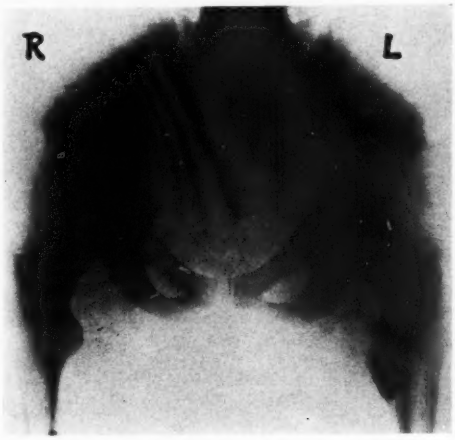

Fig. 1. Case 1. Large bony shadow in region of left hip joint of hemophiliac, probably present for a long while. Examination, made for recent pain in right hip joint, was negative.

X-ray Examination.—On Aug. 16, 1932, examination of the pelvis and hip joints revealed no change in the right hip joint, the site of the recent pain. However, there was a definite large bony shadow

near the left hip joint, which may be associated only with this hemophilic history.

Case 2. White, male, aged 12 years. The patient was a hemophiliac, with ankylosis of the hip. The knees and elbows showed slight changes, apparently chiefly developmental. A first cousin and an uncle were hemophiliacs.

X-ray Examination.—Roentgenograms made on Aug. 30, 1932, showed a juvenile pelvis. There was bone absorption around the acetabular cavity on both sides, with ankylosis on one side and shortening. From the history, the diagnosis was hemophilia of the joints.

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REPORT OF COMMITTEE ON STANDARDIZATION OF X-RAY MEASUREMENTS

SUBMITTED FOR THE COMMITTEE BY LAURISTON S. TAYLOR, CHAIRMAN[1]

CONTENTS

I. Recommendations to be submitted to the International X-ray Units Committee;
II. Discussion of the Recommendations;
III. 1931 Recommendations by the International Committee.

I. RECOMMENDATIONS TO BE SUBMITTED TO THE INTERNATIONAL X-RAY UNITS COMMITTEE

1. The International Unit of X-radiation shall be called the "roentgen" and shall be designated by the symbol r (lower case letter).

2. The roentgen is the quantity of x-radiation which, when the secondary electrons are fully utilized and the effects of scattered radiations avoided, produces in 1 c.c. of atmospheric air at 0° C. and 76 cm. mercury pressure, such a degree of conductivity that one electrostatic unit of charge is measured under saturation conditions.

3. Irradiation expresses the quantity per unit time; it shall be given in roentgens per minute (r/m) as measured in air.

4. All data given in roentgens shall apply to the incident radiation, excluding scattered radiation.

5. Inasmuch as the determination or calculation of tissue dose, representing the amount of radiation received by the skin or any part of the irradiated tissue is uncertain, all data relating to tissue dose (sum of incident radiation and scattered radiation in the tissue) shall be designated as "tissue dose" if expressed in roentgens.

6. Since satisfactory agreement regarding methods for measuring the roentgen has been established between the several National Standardizing Laboratories, various standard methods may be employed to establish the unit.

7. Secondary ionization chambers shall be calibrated against the standard chamber for the range and purpose for which they will be used. It is desirable that the relation of such chambers to the standard chambers vary as little as possible with wave length.

8. The practical instruments employed for the measurement of x-rays shall be designated as follows:

(*a*) "Irradiometer," an ionization instrument which gives a continuous indication of the irradiation.

(*b*) "Roentgenometer," an ionization instrument which measures the quantity of x-radiation (time integral of irradiation) in a given deflection of the indicator.

9. The constancy of the calibration of an irradiometer or roentgenometer shall be tested by the ionization produced in the measuring chamber by means of gamma radiation under fixed conditions from a definite quantity of radium element. Such measurements shall be suitably corrected for the atmospheric temperature and pressure under which the tests are carried out.

10. Specification of the quantity of x-radiation shall always be accompanied by a specification of the quality of the x-radiation. Quality is the wave length energy distribution in the x-ray spectrum. For most practical purposes the quality of the x-radiation may be satisfactorily specified in terms of the copper or aluminum absorption curve combined with a statement of the initial filtration. In lieu of an absorption curve, the equivalent constant potential applied to the tube terminals to yield the same curve may be stated as a single numerical magnitude. Up to 100 K.V. (constant) aluminum ab-

[1] The preparation of this report was begun under the chairmanship of E. C. Ernst, M.D.

sorption curves and above 100 K.V. (constant) copper absorption curves shall be used to establish the equivalent potential.

11. The report of a roentgen treatment shall include, in addition to the total number of roentgens and the quality, the following factors:

(*a*) Durations of, and intervals between, irradiations;

(*b*) Distance from target to skin;

(*c*) Size of field.

II. DISCUSSION OF THE RECOMMENDATIONS

¶ 1.[2] Regarding the name and symbol for the International Unit of X-radiation, emphasis should be directed to its use in relation to units in other fields. The name should always be spelled with a small r, and the symbol always a small (lower case) r. Use of the term "r-unit" or "roentgen-unit" should be deprecated since such expressions are entirely out of keeping with accepted physical nomenclature. (See note in RADIOLOGY, 1930, XV, 305.)

¶ 2. Some serious objections had arisen regarding the wording of the definition of the roentgen and the definition itself. The question before the Committee was how far to go in recommending changes in an internationally accepted definition, and it was decided to change the definition as little as possible but still bring it into an unambiguous and more usable form. At the same time, the Committee wishes to put itself on record as preferring a definition which has a better physical foundation.

In March, 1928, this Committee recommended a definition for the unit of "Effective X-ray Intensity." It is still felt that such a definition would be superior to the present one, in that it defines an x-ray beam in terms of intensity rather than quantity. By defining the roentgen as an intensity, much of the confusion in expressing dosage would be avoided. Since the quantity definition is now so widely used, the Committee does not urge this change unduly.

The present international definition has, however, a potentially embarrassing omission. It is only by fortunate circumstance that this omission has not already caused difficulty, in that below 150 K.V. (r.m.s.) its effect is almost negligible. The present definition does not mention scattered radiation, and it may thus be assumed that in measurements of the roentgen, the effect of scattered radiation may be neglected. However, one of the most important uses of the roentgen, particularly at higher voltages, is to permit a proper evaluation of x-ray dosage in comparison with that at ordinary voltages. It is necessary, therefore, that over the whole voltage range the roentgen be the measure of a quantity which can be translated into actual energy absorbed by tissue. Since the roentgen is proportional to the energy *absorbed from the beam by air*, it is necessary, therefore, to restrict conditions so that the absorption will be known. At tube voltages below 150 K.V. (r.m.s.) the absorption is largely photo-electric, whereas at the higher voltages, absorption is due principally to the energy removed from the beam by the recoil electrons in the Compton scattering process. (This is discussed in detail by C. C. Lauritsen, Am. Jour. Roentgenol. and Rad. Ther., 1933, XXX, 380–387 and 529–532.)

The question then arises as to whether the definition should or should not include the effect of scattered radiation. If it should, we are confronted with the problem of how to devise an apparatus which will definitely include all of it. Technical difficulties at the higher voltages—above 150 K.V. (r.m.s.)—seem at present to render this impossible. Should we then include only a definite fraction of the scattered radiation in the measurement and, if so, what shall that fraction be and how shall we define and determine it? As this does not appear feasible with our present knowledge the only alternative in making measurements is to avoid all effective secondary radiation as far as possible, and

[2] Paragraph numbers refer to the new recommendations given in Section I.

to reword the definition so as to embody the necessary conditions.

Our recommended definition appears to be capable of realization at high voltages without going to excessively large ionization chambers. Photographs made in a Wilson cloud expansion chamber 30 cm. in diameter (Lauritsen) show that for a narrow 700 K.V. x-ray beam practically all of the ion paths are confined within 10 cm. of the beam, and the bulk of them within the geometrical beam. Furthermore, it is seen that practically no ion tracks *originate* in the space outside the geometrical beam. This shows clearly that (1) the effect of radiation scattered from the chamber walls is negligible, and (2) there is no appreciable ionization due to photo or recoil electrons produced by secondary (degraded) radiation scattered out of the main beam. (The presence of tracks originating outside the beam indicates the entrance of a scattered quantum into that region, with the subsequent collision with an air atom and the production of measurable ions.)

The objection might be raised that, whereas the definition of the roentgen definitely excludes scattered radiation, it is impossible to realize this condition experimentally. It must be pointed out, however, that it appears to be possible experimentally to include not more than 1 per cent of the measured ionization as due to scattered radiation. Furthermore, it is possible to make rough corrections for the effect of the remainder of the scattered radiation and thereby reduce its net effect to less than 1 per cent of the total. Thus, although we cannot quite realize the ideal definition, its value is in no way impaired.

The newly defined definition can be realized by the use of: (1) suitable diaphragms to stop secondary x-rays and secondary electrons from the filters and diaphragm edges from reaching the measuring volume; (2) a narrow and well-defined x-ray beam, and (3) materials of low atomic number for the walls and electrodes of the chamber. If the diameter of the beam is sufficiently small in comparison with the distance in which the beam loses, say, half its energy, then the fraction of the degraded radiation which is absorbed in the measuring volume directly, or scattered back from the surroundings, may be neglected. Since the energy absorbed from the beam is transferred largely to recoil electrons and thence to ions, it may be determined directly from the measured ion current which gives the number of ion pairs. It is obvious that the inclusion of an appreciable amount of scattered radiation would render such a determination very uncertain at best.

It will be noted that in the proposed new definition of the roentgen we have deleted the phrase "and the wall effect of the chamber avoided." This is done for simplicity since "wall effect" merely refers to secondary radiation, and by the new definition "scattered radiations avoided" covers this also.

Confusion in the present international definition is also brought about by the consecutive inclusion of the terms "conductivity," "e.s.u. of charge," and "saturation current," which frequently leads to a misinterpretation of the definition by physicists and engineers who are not thoroughly conversant with the field; hence, the change from "at saturation current" to "under saturation conditions."

The considerations outlined above led the Committee to consider ideal physical definitions of the roentgen which would avoid any possible ambiguity, such as exists with the present definition. One such definition might be of the following form:

"The roentgen is the time integral of that flux density of radiation which, when the secondary electrons are fully utilized and the effects of all scattered radiation avoided, produces in one gram of air one electrostatic unit of charge in ion pairs." The quantity of radiation corresponding to the unit under this particular definition would be about $^1/_{800}$ that of the present roentgen. To make the unit, under this definition, of the same size as the present roentgen would necessitate a change in the definition from 1 e.s.u. to 773.4 e.s.u. or a

change from 1 gram of air to 0.001293 gram. Another possible improvement in the definition might be obtained by substituting for the last phrase in the definition above, "produces in 1 gram of air, 1,621 $\times$ 10^9 ion pairs." This last would be in agreement with the present international definition.

It should also be pointed out in connection with our proposed definition that the term "secondary radiation" may itself need further definition. This is particularly so at x-ray potentials in excess of 1.2×10^6 volts where it may be necessary to consider the effect of neutrons, protons, recoil nuclei, etc. Thus a rewording of the definition along the following lines may be indicated: "The roentgen is the quantity of x-radiation which, when all electrons and positive ions produced by secondary processes and processes of higher degree are measured, and the effects of all scattered radiations involving interaction of material outside of the measuring volume are avoided, produces in one gram of air one electrostatic unit of charge in ion pairs." It is obvious that with the increasing use of ultra-high voltages the present definition of the roentgen should be subjected to a very close scrutiny.

¶ 3. The term "irradiation" is substituted for "intensity" to avoid confusion caused by analogies between x-ray definitions and light definitions. With the roentgen defined as above for the *quantity* of x-radiation, the term "intensity" should not be used to describe the number of roentgens per unit time. To preserve the analogy to the universally accepted light definitions, use of the term "intensity" would require a different definition of the roentgen. The term "irradiation" has been used sufficiently in the sense of the above definition to warrant its general acceptance. The use of this term to express the roentgens per unit time offsets the disadvantage involved by defining the roentgen as a "quantity" of radiation.

To avoid troublesome fractions, irradiation is given in roentgens per minute (r/min.) rather than in roentgens per second, inasmuch as irradiations used clinically are usually greater than 1 if expressed in r/min.

¶ 4. This paragraph has been reworded to avoid the self-contradiction of ¶ 5 of the 1931 International Recommendations (see Section III). Since the roentgen is defined in terms of the ionization in free air, measurements made with a thimble chamber on the skin or at a depth (both producing scattering) are not in terms of true roentgens because of the wall effect. For measurements made on the skin or at a depth, the results must be described in some unit other than the roentgen. This emphasizes the need for a unit of tissue dosage, and such a unit is now under consideration by the Committee.

¶ 5. This is to amplify ¶ 4 above and show how to designate such measurements as are made where tissue scattering is included.

¶ 6. This replaces ¶ 4 of the 1931 International Recommendations, which was more or less without significance. It serves to emphasize the fact that there is generally satisfactory agreement between the x-ray standards of several countries. It should not, however, be obligatory to use different standardization methods.

¶ 7. This is principally a rewording of ¶ 6 of the 1931 International Recommendations to emphasize the need for calibrating secondary ionization chambers for the *exact* purpose for which they will be used.

¶ 8. The term "dosage meter" for the practical clinical measuring instrument has led to a great deal of loose thinking and misconception regarding the significance of roentgen measurements in the radiologic clinic. A dose is a product of the number of roentgens by some factor which takes all scattering into consideration, hence, it is obviously impractical with our present knowledge to devise a simple physical instrument to measure such a quantity. The secondary instruments ordinarily employed measure only in terms of roentgens and, as shown above, are only strictly valid when measuring the beam without

scattering. Measuring instruments fall into two distinct classes—one which measures the irradiation of a beam and the other which measures the quantity of radiation in a given time. To avoid confusion and avoid use of the term "dosage meter," it is desirable to distinguish between these two classes of instruments.

¶ 9. Control of the constancy of a secondary measuring instrument according to the 1931 International Recommendations is not necessarily positive unless the ionization is produced in the chamber itself by the gamma rays. (For example, a gamma ray test applied to the electroscope or an auxiliary chamber would not necessarily detect a broken collector electrode in a thimble chamber.) Control measurements made in accordance with the above will invariably detect faults in the instrument. There is no doubt but that irradiometers and roentgenometers will eventually be in the same class as voltmeters and ammeters, and that the methods for testing their constancy will be abandoned. If such instruments are reliably and ruggedly constructed, then methods for testing their constancy should not be required outside of the calibration of the instrument with a standard air chamber.

¶ 10. (Replacing ¶ 9 of the 1931 International Recommendations.) In the past, radiation qualities have been expressed in a variety of ways, most of which have their favorable aspects. These included half value layers in copper or aluminum, effective wave length (5 varieties), average wave length, and full absorption curve. The half value layer method has been most generally used (at least abroad) but, as in the case of the full absorption curve, requires a number of separate measurements for its determination. The full absorption curve method has been repeatedly shown theoretically and experimentally to give an adequate representation of the composite radiation quality, and from such a curve all other expressions of quality may be directly derived. Thus the future use of such a curve for expressing quality will permit immediate correlation with all quality data presented in the past by whatever method. This is not readily possible with any other methods now in vogue.

A difficulty in the past in the use of a full absorption curve for describing quality was the inability to express it as a single numerical magnitude. However, this may now be avoided by referring as a base to the absorption curves obtained with constant potential. Thus an absorption curve starting with a stated filter may be expressed by the constant voltage necessary to produce it, and hence all qualities of radiations may be reduced to terms of an equivalent constant potential. Such a method is of distinct advantage in comparing x-ray beams produced by generators of widely different wave forms. This is also important at voltages up to 1,000 K.V., such as are now being used in this country clinically. The voltage wave form of such generators vary from a constant one to one with very narrow peaks, and at a given peak voltage the quality and effectiveness may vary between wide limits. By comparing the absorption curves of such radiations with the absorption curve for a constant potential, they may all be reduced to a common base and the voltages may all be expressed as some equivalent voltage.

¶ 11. (Replacing last sentence of ¶ 9 of the 1931 International Recommendations.) The requirement has been added that, in reporting a roentgen treatment, the skin-to-target distance be given. The need for this is obvious because of the influence of the skin-to-target distance upon the percentage depth dose.

III. 1931 RECOMMENDATIONS BY THE INTERNATIONAL COMMITTEE

(1) The International Unit of X-radiation shall be the quantity which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in 1 c.c. of atmospheric air at 0° C., and 76 cm. mercury pressure, such a degree of conductivity that one electro-

static unit of charge is measured at saturation current.

(2) The International Unit of X-radiation shall be called the "roentgen" and shall be designated by the letter "r."

(3) The "intensity" of the radiation shall be expressed in r per second.

(4) Various standard methods shall be employed to establish the unit.

(5) All data given in roentgens (r-units) shall be supplied with an index to distinguish between the incident dose which does not include the scattered radiation, and the effective dose which includes the scattered radiation.

(6) For all comparative purposes it is advisable to employ ionization chambers which have been calibrated in terms of a standard chamber for x-radiation of the various qualities employed. It is also advisable to make the wall effects of these chambers as small as possible.

(7) The practical instrument used to measure x-ray output shall be called a dosage meter (dossismesser, dosimetre).

(8) The constancy of the indications of the dosage-meter shall be tested by means of gamma radiation emitted from a definite quantity of radium element, the measurement being carried out always under the same conditions.

(9) Any specification of dosage is incomplete without specifying the quality as well as the quantity of the radiation. For practical purposes it suffices to specify the quality of the x-radiation in terms of the half value layer in copper when this value exceeds 0.1 mm. of copper, or in terms of the half value layer in aluminum for radiation of less penetration; in all cases the value of the maximum voltage applied to the terminals of the tubes shall be stated. The specification of the dosage shall also include in addition to intensity and quality such factors as the intervals between the times of irradiation and size of field.

The International X-ray Unit Committee further recommends that:

(1) The experimental methods of establishing a standard for the determination of the International X-ray Unit shall be entrusted to a sub-committee consisting of the following members of the Unit Committee: M. de Broglie (France), W. Friedrich (Germany), E. A. Owen (Great Britain), R. Sievert (Sweden), I. Solomon (France), E. Pugno Vanoni (Italy), L. S. Taylor (U.S.A.), (Honorary Secretary of the Committee, E. A. Owen). This Committee shall invite the collaboration of the various existing national bureaus for standard measurements and also those about to be instituted.

(2) This Committee shall consider: (*a*) methods of controlling the constancy of dosage meters; (*b*) the correlation of x-ray and gamma-ray dosage; (*c*) the establishment of a gamma-ray unit of intensity.

(3) The progress of the work done by the sub-committee shall be reported once a year to the members of the International X-ray Unit Committee.

(4) Each country shall be requested immediately to elect its two representatives on the International X-ray Unit Committee; until new representatives are elected the present members shall serve.

(5) The International Committee shall henceforth be called "The International Committee for Radiological Units."

Approved by the Committee in Chicago, Sept. 27, 1933.

THE SIGNIFICANCE OF OSSEOUS CHANGES IN THE ROENTGENOGRAPHIC DIAGNOSIS OF TUMORS OF THE SPINAL CORD AND ASSOCIATED SOFT TISSUES[1]

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DESPITE continued refinements in neurologic diagnosis which have contributed to earlier recognition of the presence of tumor of the spinal cord, roentgenology, except for the employment of lipiodol advocated by Sicard and Forestier (13), in 1922, contributed little until recent years toward the diagnosis and localization of these tumors. Even after the advent of Sicard and Forestier's method, which directed the attention of roentgenologists to these lesions, few attempts were made to search for other roentgenologic criteria, despite the repeated observations by neurosurgeons (1, 2, 3, 6, 8) that changes in bone not uncommonly accompany such tumors. Pancoast (11), in 1918, and Carman and Davis (5), in 1924, were the first roentgenologists to comment on the value of roentgen rays in the direct diagnosis and localization of these tumors. Pancoast stated: "Tumors of the spinal cord cannot be diagnosed by this method, and if by any chance they involve the vertebræ secondarily, the appearance is in no way suggestive of their primary origin." Carman and Davis were the first to record the incidence of direct roentgenographic changes in any series of tumors of the spinal cord. In a series of 119 cases, they elicited roentgenographic evidence of involvement of bone in only three instances (2.6 per cent), from which they concluded that the practical value of direct roentgenologic examination was slight, and that it was impossible to demonstrate tumors themselves by this method. Stimulated by the experience of Adson, and his contention that many of these bony changes should be discernible roentgenographically, and hopeful that improvements in roentgenographic technic had increased the incidence of their recognition, Adson and I decided to review all the available roentgenograms in the cases of tumor of the spinal cord in which operation had been performed at The Mayo Clinic before 1931. This study (4), presented in detail about two years ago, showed that changes in bone, particularly erosion resulting from contiguous tumor of the spinal cord or associated soft tissues, could be observed roentgenographically in about 20 per cent of all cases.

Because of the significance of these changes and their value in permitting exact localization of the tumor roentgenographically, without additional measures, observations have been continued in all subsequent cases in which tumor of the spinal cord has been suspected. An effort has been made to establish the significant roentgenologic changes associated with the various types of tumors and their incidence under improved roentgenologic methods. The results have been most encouraging, for in that group of cases of tumor of the spinal cord in which operation was performed at The Mayo Clinic between Jan. 1, 1930, and Sept. 1, 1933, osseous changes which directly localized the lesion were observed roentgenographically in 50 per cent. The percentage of cases in which osseous changes were detected varied considerably, as might be expected, with the different groups of tumors. This will be seen from the following figures concerning the more common lesions: neurofibroma, 65 per cent; endothelioma, 11 per cent; ependymal-cell glioma (caudal tumors), 66 per cent; hemangioma and hemangioendothelioma, 33 per cent; intramedullary tumors (exclusive of ependymal-cell glioma), none.

The significance of this improvement in roentgenologic diagnosis can be appre-

[1] Presented before the First American Congress of Radiology, Chicago, Sept. 25–30, 1933.

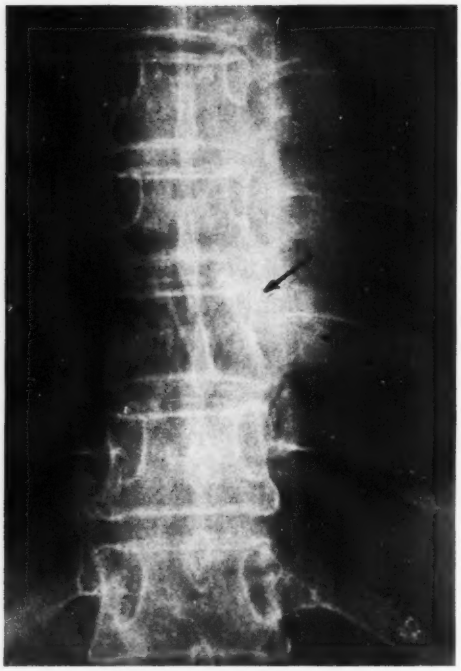

Fig. 1. Localized erosion of left pedicle of ninth thoracic vertebra produced by contiguous neurofibroma. Symmetry of the normal pedicles, above and below the site of the tumor, may be noted.

ciated when it is recalled that similar changes were observed in only 2.6 per cent of Carman and Davis' cases. Confidence in the significance of these changes, which were confirmed by subsequent operation, has enhanced the clinical differential diagnosis of lesions of the spinal cord and has enabled the surgeon in many cases to locate the growth exactly, without the use of a radiopaque oil to establish the diagnosis or the level of the tumor.

TECHNIC OF EXAMINATION

In the roentgenographic examination of a patient suspected of having a tumor involving the spinal cord, roentgenograms of the spine taken in the anteroposterior and lateral directions are necessary. These should be supplemented by stereoscopic and occasionally oblique views localized over the suspected site of the lesion. The Potter-Bucky diaphragm, and a fine-focus tube, are indispensable. Accurate positioning of the tube and patient is essential, since any distortion of the vertebral shadows may be misleading.

In interpretation of the roentgenograms

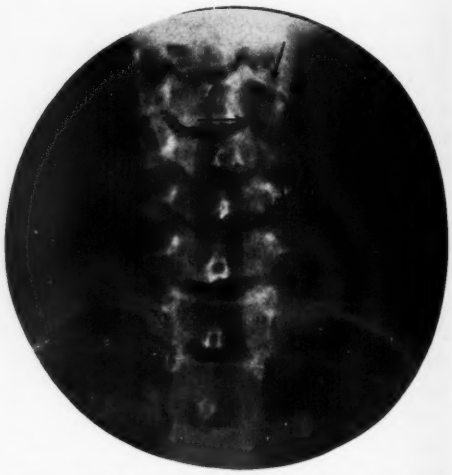

Fig. 2. Erosion of left pedicles of fourth and fifth cervical vertebræ and enlargement of intervertebral foramen produced by dumb-bell-shaped neurofibroma extruding through intervertebral foramen from spinal canal.

the chief concern is with alterations in the structure of the vertebræ or adjoining ribs, and a satisfactory film should show all parts of these clearly. In the past, insufficient attention has been paid to the shadows of the vertebral pedicles and laminæ, since these structures usually present evidence of a contiguous tumor before it is discernible in the body of the vertebra. Changes in the shadows of the paravertebral soft tissue may portray extravertebral extension of a neoplasm; hence an exposure, particularly to show these structures, may be necessary if they are not delineated in the roentgenogram of the spine that is made as a routine.

CLASSIFICATION

As the title indicates, this paper is concerned only with tumors of soft tissue arising within the spinal canal and it is this group that is of particular interest to the

neurosurgeon. For practical consideration by the roentgenologist they may be classified as: (1) benign tumors arising from soft tissues within the spinal canal; (2) malignant tumors arising from soft tissues within the spinal canal, and (3) tumors and protrusions of the intervertebral disc, involving the spinal canal.

Benign Tumors Originating within the Spinal Canal.—The most common tumors of this group include neurofibroma, endothelioma (meningioma), hemangioma, angioma, lipoma, and dermoid cyst. Ependymal-cell glioma (ependymoma) is included in this group because roentgenologically it resembles a benign tumor. All of these tumors involve the bone in a similar manner; that is, by erosion from pressure. They have no individual distinguishing roentgenologic characteristic except the neurofibromas, which have a tendency to extrude through an intervertebral foramen, producing an hour-glass tumor partly within and partly without the spinal canal. As the tumor enlarges, the adjacent portions of the vertebra are eroded by direct pressure and pulsation of the spinal cord and vessels. The margins of the eroded area are sharply demarcated and coincide with the surface of the contiguous tumor or displaced spinal cord. These changes rarely occur in the absence of partial or complete block of the spinal canal, unless the tumor is held in contact with the bone by a nerve root or meningeal attachment. One or both pedicles of the vertebra at the level of the tumor usually exhibit evidence of erosion before it can be discerned in the laminæ or body. The pedicle is first flattened on the medial aspect and the cortical bone is rarefied. As the tumor grows the surface of the pedicle becomes concave, coinciding with the surface of the mass (Fig. 1), and lastly it is entirely destroyed. At this stage, if the tumor is a neurofibroma, it may extend along the course of the posterior nerve root and extrude through the intervertebral foramen which it also erodes and enlarges (Fig. 2). Later, as the tumor within the canal enlarges, the pedicles of several vertebræ may be involved, and at this stage neurologic signs are usually definite (Figs. 3 and 4). In the interpretation of changes in the pedicle, one must not be misled by the unilateral pseudo-narrowing of pedicles incident to scoliosis and rotation of the spine. Anatomic variations in the size of pedicles should be distinguished from changes resulting from tumor, by involvement in the former case, of several vertebræ and the absence of neurologic signs.

Fig. 3. Erosion of pedicles of eleventh and twelfth thoracic vertebræ and right intervertebral foramen produced by contiguous dumb-bell-shaped neurofibroma.

Rarefaction of the laminæ occurs early but is rarely recognized in the roentgenogram until fairly advanced, because in both the anteroposterior and lateral views the shadows of other structures are superimposed. When the tumor is extradural, erosion and rarefaction of the laminæ may exactly coincide with the surface and out-

line of the growth. Ependymal-cell gliomas may attain large size and produce complete absorption of the contiguous lamina.

Erosion of the body of a vertebra is usually recognized later than changes in the pedicles or laminæ. The erosion may be localized and discrete, coinciding with the shape of an adjacent tumor, or the body may be uniformly flattened or hollowed out on its posterior surface if the neoplasm is large (Figs. 5 and 6). The intervertebral discs and median raphé are particularly resistant to erosion from pressure, and in the presence of large tumors, particularly ependymal-cell gliomas of the cauda, the posterior surfaces of the bodies of the vertebræ exhibit a deep concavity on either side of the median raphé (Fig. 7). Occasionally an unusually large benign tumor may erode the vertebra to such a degree that pathologic fracture occurs, with resultant structural deformity. Benign antesacral tumors, especially dermoids, may grow to considerable size within the pelvis before the true nature of the lesion is realized. Occasionally they may be recognized by the shadows of teeth or bone.

Sixty-five per cent of the neurofibromas in this series produced localizing roentgenographic signs in contiguous vertebræ. Not uncommonly, such a tumor in the thoracic part of the spine will extrude through an intervertebral foramen into the thorax and produce a shadow that may be confounded with a mediastinal or pulmonary neoplasm (Fig. 8). Endotheliomas (meningiomas), because they tend to be smaller, harder, and to grow more slowly, produce osseous changes less frequently (11 per cent of cases) than some other neoplasms of this group. The changes which accompany this tumor are usually quite localized. Many of these tumors contain calcareous psammoma bodies, and occasionally the calcium is sufficient to be discerned in the roentgenogram, thus making possible

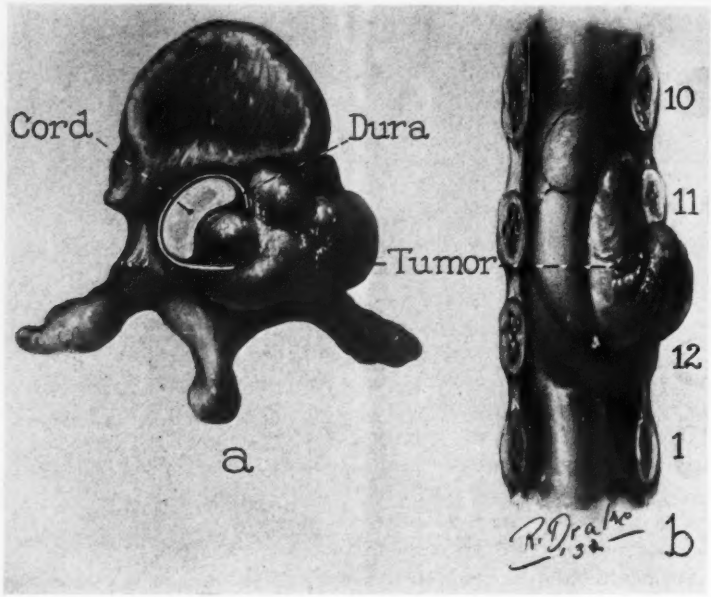

Fig. 4 Artist's drawing, showing dumb-bell-shaped neurofibroma *in situ* and relation of tumor and cord to contiguous bony structures which have been eroded by pressure. (See Fig. 3.)

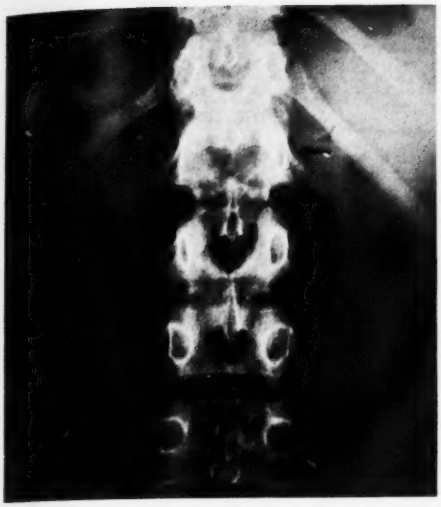

Fig. 5. Anteroposterior view, showing erosion of pedicles and lamina of first lumbar and left pedicle of second lumbar vertebræ, produced by intraspinal neurofibroma.

Fig. 6. Lateral view, showing enlargement of spinal canal and erosion of posterior surface of bodies of first and second lumbar vertebræ. Intraspinal neurofibroma. (See Fig. 5.)

identification of the tumor (Fig. 9). According to Kernohan, Woltman, and Adson (9), ependymal-cell gliomas (ependymomas) constitute 68 per cent of all tumors originating in the filum terminale. In this series, 66 per cent of the ependymal-cell gliomas had produced erosion of bone; hence, the presence of such a tumor is suggested when significant osseous changes are discerned in the lumbosacral region. Early recognition of these changes may be obscured by the presence of spina bifida.

Angiomas and hemangiomas produce secondary changes in bone similar to the changes caused by other tumors in this group, but the rarefied bone is likely to be spongy and to bleed freely. They seem to have a predilection for the thoracic region, especially as indicated by this series.

Malignant Tumors Arising from Soft Tissues within the Spinal Canal.—Tumors of this group include both primary and metastatic lesions. The intramedullary tumors, particularly the gliomas with the exception of ependymal-cell gliomas which already have been considered, do not commonly involve the vertebræ secondarily. Since these tumors originate within the spinal cord, serious neurologic signs usually occur long before the growth has expanded the cord sufficiently to erode the surrounding bone. The other tumors, consisting chiefly of various forms of sarcoma, lymphosarcoma, malignant hemangio-endothelioma, and metastatic growths, destroy the surrounding vertebræ by direct infiltration, and thereby produce the well-recognized roentgenologic picture of malignant disease in bone. Extension into the paravertebral tissues is not uncommon. Rarely, from the secondary changes in bone, can the primary or metastatic nature of malignant tumors of soft tissue be predicted except as similar changes may be observed in other regions of the spine.

Tumors and Protrusions of the Intervertebral Disc Involving the Spinal Canal.—

Fig. 7. Erosion of fourth and fifth lumbar vertebræ and sacrum produced by pressure from large intraspinal ependymal-cell glioma. The margins of the eroded bone are sharply defined.

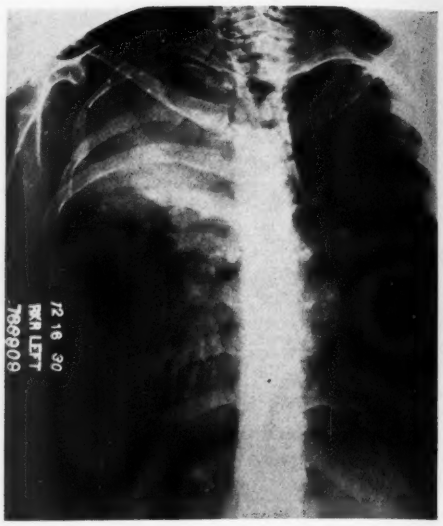

Fig. 8. Dumb-bell-shaped neurofibroma, with extensive intrathoracic extension. Note destruction of left pedicle of third thoracic vertebra, enlargement of intervertebral foramen, and erosion of third left rib posteriorly, with widening of intercostal space.

These are termed by Elsberg "ecchondroses" (7), and, in his experience, they constitute 14 per cent of tumors of the spinal cord. They are most common in the cervical portion of the spine. Two types should be distinguished: (1) true tumors, comprising chondromas, fibrochondromas, and fibromyxochondromas, which usually grow rapidly in the line of least resistance toward the spinal cord which they compress, and (2) traumatic prolapse of the intervertebral disc into the spinal canal. Because of their cartilaginous nature these masses are not themselves visible in roentgenograms; however, the tumor, because of its growth, may widen the posterior portion of the intervertebral space and even erode contiguous bone. In the traumatic variety, the intervertebral space is narrowed because of previous compression and prolapse of a portion of the disc. Secondary thickening of the contiguous vertebral margins may occur. Calcification and even ossification of these intraspinal protrusions have been noted by Schmorl (12). In doubtful cases, injection of a radiopaque oil into the subarachnoid space may disclose the situation of the lesion.

DIFFERENTIAL DIAGNOSIS

Since the symptoms of tumor of the spinal cord are largely the result of compression of the cord, nerve roots, or both, differential diagnosis of these lesions, by the roentgenologist, involves the consideration of any deformity or disease-process that is capable of producing compression of the cord or nerve roots. For practical consideration, the conditions other than those previously mentioned may be listed as: (1) inflammatory disease of the spine and meninges, (2) benign tumors of the vertebræ, (3) malignant tumors of the vertebræ, (4) non-neoplastic lesions of the

Fig. 9. Calcified intraspinal dural endothelioma (meningioma) overlying shadows of fourth and fifth thoracic vertebræ.

Fig. 10. Destruction of sacrum by chordoma.

vertebræ, and (5) congenital anomalies of the spine.

In considering the distinction of these conditions from osseous changes associated with tumors of the spinal cord it is important to bear in mind that the bone is only secondarily involved in the case of tumor of the spinal cord and that the changes are erosive if the lesion is benign, and infiltrative if the growth is malignant. The extent of destruction depends on the size of the contiguous tumor of soft tissue. It is noteworthy that, in this series, no tumor of the spinal cord had caused secondary proliferative changes in the vertebræ that could be discerned roentgenographically; hence, a vertebral lesion which exhibits osteogenic properties is, in all probability, not the result of a contiguous tumor of the spinal cord. The so-called spongy hypertrophy of bone sometimes encountered by neurosurgeons, contiguous to a tumor, has not been demonstrated roentgenographically in my experience. This is probably a change resulting from atrophy of bone secondary to pressure from the neoplasm or to circulatory change in the bone resulting from irritation by the mass.

Inflammatory and Degenerative Disease of the Spinal Cord and Meninges.—Examples of vertebral involvement secondary to these conditions are exceedingly uncommon. I have observed one case in which erosion of a pedicle was produced by a contiguous localized cyst in a case of chronic cystic arachnoiditis. The osseous change was identical to that which might have been caused by a contiguous benign neoplasm. Generally speaking, these lesions do not involve the vertebræ and are discerned only after injection of radiopaque oil into the subarachnoid space.

Benign Tumors of the Vertebræ.—These tumors include osteomas, osteochondromas, chondromas, fibrochondromas, giant-cell tumors, and hemangiomas. All of these tumors which may involve the spinal cord by secondary compression, exhibit the same roentgenologic characteristics in the vertebræ as in the skeletal system elsewhere. The osteomas and osteochondromas, which are osteogenic in nature, should not be confounded with the changes caused by a tumor of the spinal cord. The chondromas and fibrochondromas may

arise from the central portion of a vertebra and thus produce early signs of compression of the cord. Since they erode the bone directly by pressure and produce a sharply defined defect in the vertebra, they may easily be confounded roentgenographically with the changes of a benign tumor of the spinal cord, particularly if the growth has originated in that part of the vertebra that is close to the canal. Fortunately, these tumors are rare and need not often concern the roentgenologist.

Giant-cell tumor usually involves the body of a vertebra, although the bony processes are not uncommonly affected. This multilocular cystic lesion, primary within a vertebra, should be readily distinguished from the localized erosion of a benign tumor of the spinal cord. In the latter instance, the changes are contiguous to, and represent an enlargement of, the spinal canal, the remote parts of the vertebra being normal. In the case of giant-cell tumor, the remote portions of the vertebra are usually involved and the bony shell delineating the wall of the spinal canal generally can be identified. Collapse of a vertebra is not uncommon in giant-cell tumor, and under such circumstances the usual characteristic roentgenographic appearance may be obscured. The resulting neurologic symptoms, however, are out of proportion to those which accompany a tumor of the spinal cord that is large enough to cause collapse of a vertebra.

Hemangioma of a vertebra produces irregular absorption and thickening of the trabeculæ of the bone, giving its structure a coarse, honey-combed appearance. This is easily distinguished from the localized erosion caused by a tumor of the spinal cord.

Malignant Tumors of the Vertebræ.—Tumors of this type, that secondarily involve the spinal cord, include all lesions, both primary and metastatic, that are found elsewhere in the skeletal system. The more common are sarcomas, myelomas, endotheliomas, metastatic carcinomas, and hypernephromas. The roentgenologic characteristics of these lesions are too well known to warrant consideration here. Except in the presence of involvement of multiple vertebræ, indicating metastatic disease, it is frequently impossible to decide whether or not the malignant disease started in the vertebra and involved the cord and surrounding tissue secondarily, or *vice versa*. The chordomas are included in this group since they arise from remnants of the notochord in the vertebræ or sacrum, and for roentgenologic consideration are essentially tumors of bone. They most commonly arise in segments of the sacrum, where they produce extensive malignant destruction and even invade the ilium and pelvic cavity (Fig. 10). They are closely imitated by metastatic malignant growths and are commonly confounded with large, lumbosacral ependymal-cell gliomas. The latter, however, should be readily distinguished by the marked difference in the type of secondary destruction of bone.

Non-neoplastic Lesions of the Vertebræ.—Proliferative changes in the laminæ, spinous processes, pedicles, and bodies, sometimes resulting in the condition that is referred to as hypertrophic osteitis, may involve one or several vertebræ. They generally represent reactions to previous trauma, localized infection, so-called hypertrophic arthritis, or spondylitis deformans. They vary in degree from localized hypertrophy, encroaching on the spinal canal, to massive fusion of several spines and laminæ. Proliferative changes about the margins of the lateral articulations are not uncommon. Spondylitic exostosis localized at the margins of one or a few contiguous vertebral bodies, the rest being normal, has been described as a frequent accompaniment of tumor of the spinal cord (10). Such changes, however, in my experience, have not occurred consistently enough to warrant such a statement. Proliferative changes in bone may occasionally develop after operative procedures on the vertebræ, but they rarely extend into the spinal canal and produce compression of the cord.

Compression fracture and fracture dislocation may cause development of bony callus, and may give rise to late signs of compression of the cord that simulate tumor of the spinal cord. A fracture may not be clearly revealed in the original roentgenogram, but as callus is formed the site of the injury becomes obvious.

Primary infections of the vertebræ, such as tuberculosis, osteomyelitis, actinomycosis, coccidioidal granuloma, and so forth, may result in abscess within the spinal canal and cause symptoms of tumor. The destructive areas in the vertebræ, together with involvement of the intervening intervertebral disc or discs, should suggest the presence of an infectious process since these structures are particularly resistant to invasion by tumor.

Congenital Anomalies of the Vertebræ.—These are common, but the actual anomaly itself is not likely to be confounded with the changes secondary to tumor, since evidences of erosion or infiltration are naturally not present. The anomaly, however, may obscure early recognition of a coincident neoplasm, particularly in the lumbosacral region, where the existence of spina bifida frequently will mask recognition of early erosive changes in the lamina.

Records in The Mayo Clinic, to March 1, 1932, disclose that 394 patients have been operated on for tumors compressing or invading the spinal cord (3). Ninety-seven (25 per cent) were situated extradurally, 196 (50 per cent) were situated subdurally but were extramedullary, and 101 (25 per cent) arose from the spinal cord or filum terminale (intramedullary). A study of the entire group of 394 cases emphasizes the fact that the greater proportion of intraspinal tumors are removable. Since our experience has shown that 50 per cent of these tumors may be localized by the primary roentgenogram, without the use of additional aids, we believe that this method of examination should occupy a prominent place in the diagnosis of these neoplasms, which, if recognized and removed early in their development, can be permanently cured.

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STANDARDIZATION OF ROENTGEN DOSAGE BY MEANS OF METHYLENE BLUE II[1]

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IN previous publications (1) we have discussed the effect of roentgen irradiation on solutions of certain colored organic substances. It was shown in particular that methylene blue was quite rapidly discolored. The amount of color change could be measured accurately by means of a spectro-photometer and could be used for determination of roentgen dosage. The advantages of such a method were also considered. We have continued the attempt to make the method practical. In order to obtain a wide field of usefulness it seemed important to so arrange it that a small amount of solution would be needed and that the solution would be surrounded exclusively by organic material during the exposure.

During these experiments the solutions were buffered so that the PH was kept constantly at 6.8.

A. Solutions.—A stock solution is made up by dissolving 0.05 gr. of purified methylene blue and making up to 500 c.c. volume with boiled distilled water, giving a concentration of 0.1 mg. per cubic centimeter.

The final solution of methylene blue used for irradiation is made up by dissolving 2.969 g. of Na_2HPO_4, $2H_2O$ and 2.2695 gr. of KH_2PO_4 in about 300 c.c. boiled distilled water. A calculated amount of the methylene blue stock solution (13.5 c.c.) is added and the solution then made up to 500 c.c. volume with boiled distilled water, giving a concentration of 0.0027 mg. per cubic centimeter. This concentration may have to be slightly adjusted to give the desired absorption. The solution has to stand one week before it can be used. How long it will keep is as yet a question—it has been found in good condition at the end of three months but has to be tested if left for a longer time.

B. Absorption.—A spectro-photometer was used for determination of the concentration before and after the exposure to roentgen rays. The absorption was measured at 6,700 Å. U., as the maximum absorption in the visible region takes place at this wave length. The smallest container (absorption tube) that seemed practical to use with our spectro-photometer measured 2 cm. in length and 1 cm. in inside diameter. Containers holding about 2.5 c.c., therefore, had to be used during the roentgen irradiation, and they had to be made from organic material. In order to obtain a suitable color intensity when a 2-cm.-long absorption tube was used, the concentration of methylene blue had to be approximately 0.0027 mg. per c.c. of water. The final concentration was adjusted so that the solution had an extinction coefficient of 0.754. An experimentally obtained curve showing the relation between the dose and the color change must be used when the method is applied for standardization.

C. Containers.—It required much experimentation before a method of making suitable containers was developed. Among the substances tested, superlawax and parlodion were found to be suitable, as they did not influence the color change of the methylene blue. When the solution was kept in shallow rectangular grooves in a block of superlawax, fair results were obtained but the errors were too large, probably due to small amounts of impurities. With such a large surface exposed to the air, too much dust may have gathered before the surface could be covered; it was found that a small amount of dust deliberately added had a pronounced influence.

[1] Read before the Radiological Society of North America at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

Parlodion can easily be dissolved in a mixture of alcohol and ether, 50 per cent of each. By coating the inside of a container (for instance, a test tube) with this solution and letting it dry, a thin coat of parlodion remains which may be removed. However, a better procedure to obtain a sealed container has been adopted. An ordinary water soluble gelatin capsule No. 13 (for veterinary use) is used as the mould. A smoothly running but fairly thick and sticky solution of parlodion is poured into the two halves of the capsule. Excess parlodion is poured out and the capsules are turned around continuously until the solution does not run any longer, whereupon they are left to dry for some minutes and a second coating is added in a similar manner. Seven such coats seem to be needed. After practically all the ether and alcohol has evaporated (in about three days), the capsules are dissolved in water and the parlodion is washed with cleaning solution and distilled water. The methylene blue solution is poured into these capsules and exposed to the roentgen rays. It was found that the first containers used became colored from some absorbed methylene blue, which meant that the solution became weaker and the readings indicated a color change even without any irradiation of the capsules. This source of error was overcome by adding a very small amount of concentrated hydrochloric acid to the alcohol and ether solution before the parlodion was dissolved. Even with the present method of making the containers, it is necessary to test them before they are acceptable. The test consists in filling them with the methylene blue solution and exposing them to roentgen rays. If successive exposures give the same amount of change, or if the change is the same as in already tested capsules, then they are ready to use. These capsules can be left filled with solution for a week in a room without showing any leakage or any other effect on the solution. When they are transported from one place to another they may, however, develop a leak, probably due to temperature variations or to violent shaking. They are, therefore, dipped in melted paraffin and thus supplied with a thin protective coating before being sent away. When the capsules are not in use they should be kept in distilled water and protected from exposure to direct sunlight.

D. Measurements.—The method has not been tested enough as yet to permit us to state whether or not it is practical for comparison of dosage at different places but we believe it may prove to be of value. The accuracy is not as great as we would like to see it, but as the procedure is very simple this method may be used at certain intervals at a great number of therapy installations to obtain a fair comparison between the dosages used. We wish to emphasize again the advantage of thus comparing the total amount of radiation absorbed at the surface or at certain "depths" by an organic solution under conditions which are similar to those during treatments and which limit the exposed parts to organic compounds and water.

In order to obtain a standardization curve, a number of exposures have been made under the following conditions: 200 K.V. peak, 30 ma., 0.5 mm. copper and 1 mm. aluminum filter were used. The containers were placed in small grooves in a block of paraffin, surrounded (but not covered) with paraffin so that the full amount of scattering was obtained from a 20 × 20 cm. field and from a layer 14 cm. thick. The distance from target to the surface of the paraffin and also to the top of the capsules was 50 centimeters. The number of roentgens per minute as measured in air with a Victoreen r meter (No. 378) amounted to 82. Since this instrument showed a considerable amount of leakage when the roentgen machine was going, it was completely surrounded by lead except for the small ionization chamber, and in this manner the leakage was made negligible. The half value layer in electrolytic copper was found to be 1.0 millimeter.

TABLE I

Decomposition of methylene blue by roentgen irradiation: 200 K.V., 30 ma., 50 cm. distance target to container, 0.5 mm. Cu + 1 mm. Al filter. Field 20 × 20 cm., paraffin 14 cm. thick; 15 min. gives approximately 1,200 roentgens (measured in air)

Time of radiation	Percentage of decomposition	Time of radiation	Percentage of decomposition
15 min.	31	45 min.	49
15 min.	31	45 min.	51
15 min.	31.5	45 min.	52
15 min.	31	45 min.	51
15 min.	30	45 min.	51
15 min.	31.5	45 min.	53
15 min.	30	Average	51
Average	31		
30 min.	43	1 hr.	62
30 min.	46	1 hr.	58
30 min.	43	1 hr.	59
30 min.	43	1 hr.	61
30 min.	44	1 hr.	62
30 min.	43	Average	60.5
30 min.	44		
Average	44		
		1 1/2 hr.	69.5
		1 1/2 hr.	70.5
		Average	70
		2 hr.	75

TABLE II

Time of radiation	Percentage of decomposition
10 min.	22
10 min.	23
10 min.	23
10 min.	24
10 min.	21
10 min.	23
Average	22.5
5 min.	14
5 min.	16
5 min.	13
5 min.	11.5
5 min.	11
5 min.	11.5
Average	13

The results of the measurements are shown in Figure 1 and Tables I and II. Each figure under "percentage of decomposition" in these tables represents the average of at least three tubes exposed at the same time. The difference in the decomposition determinations between the individual tubes, irradiated together for 15 minutes, runs as high as ±5 per cent. The readings can be made with greatest accuracy when about 30 per cent of the methylene blue has been destroyed, an amount of change which requires 15 minutes, or, according to the roentgen meter (No. 378), 1,200 roentgens to obtain. This corresponds to 150 per cent of our erythema dose. When the capsules are mailed to other offices they should be exposed, therefore, to approximately 1,200 roentgens (as measured in air). The readings corresponding to this part of the curve show an individual variation of about ±5 per cent in dosage. The errors when comparing doses should not exceed, therefore, this amount, as three capsules are supposed to be exposed at a time and at least two of them ought to come back in good shape.

The following procedure is now used. A cardboard box 8 × 12 × 3 cm. is filled with melted paraffin. After this has hardened, five grooves are made by means of a heated metal tool (fastened to a handle) of the same size and shape as the capsules. These grooves are numbered and in them are placed the paraffin-sealed containers filled with the methylene blue solution. Figure 2 shows the distribution. The box is covered and wrapped in cotton. A note of instructions is added and the package is sealed and mailed by special delivery.

INSTRUCTIONS: READ THIS BEFORE OPENING THE PACKAGE

1. Keep the containers in the dark except during the exposure, as the methylene blue is slowly discolored by light and especially by ultra-violet radiation.

2. The exposures to x-rays ought to be made and the package returned as soon as possible, preferably within 24 hours.

3. Containers No. 1 and No. 2 in the outside grooves should be removed before any exposure is made. In order to obtain full amount of scattered radiation the two empty grooves should be filled with water, and the small paraffin block placed on a larger block and also be surrounded with, but not covered by, paraffin. The total thickness of paraffin should be at least 10 centimeters. A 20 × 20 cm. field should be used.

4. Containers No. 3, No. 4, and No. 5 should be exposed under the desired conditions (we propose 200 K.V., 50 cm. distance from target to top of container, 0.5 mm. copper plus 1 mm. aluminum filter).

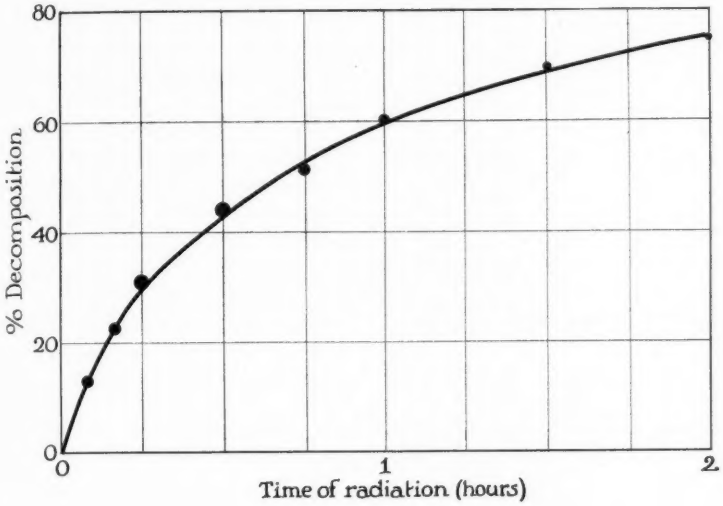

Fig. 1. See text.

The dose given should be about 150 per cent of an erythema dose (1,200 roentgens as measured in air without back-scattering). The dose should in any case lie between 120 and 250 per cent S.E.D.

5. After the exposures have been made the grooves should be dried out and the containers replaced in their respective pockets and the box mailed back. The amount of exposure given and the arrangement used should be written down and included in the package.

When returned, the tubes are immediately inspected with care for damage. Even a slight amount of evaporation from a tube makes it necessary to discard its solution. If the tubes are covered with a filter paper during the entire trip and some solution leaks out, then this paper becomes stained. A more accurate test for leakage or evaporation is to weigh the tubes before and after their journey. If neither of the two unexposed tubes are intact or if the readings of their solution do not check with the previous readings, no satisfactory information can be obtained and this particular shipment would be a failure.

It is evident that measurements of this type can be carried out only where spectrophotometers are available and that it requires some training to obtain satisfactory accuracy in taking the readings. With the description given in this and two earlier papers it should be relatively easy to prepare the solutions and the containers in a laboratory and to duplicate dosage measurements according to the method here outlined.

It is evident that the capsules with the solution can be used in several different ways to measure dosage distribution. Our first attempt is, however, to use them as described above, to facilitate standardization of different machines.

SUMMARY

1. A method of using a water solution of methylene blue to measure roentgen dosage is described.

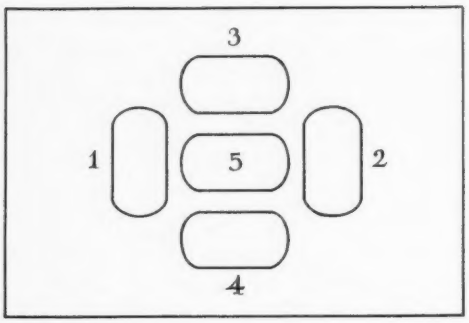

Fig. 2. Distribution of capsules in paraffin block.

2. A spectro-photometer is used to determine the color change.

3. The solution is buffered to a PH of 6.8. The exact method of preparing this solution is described.

4. Small capsules of parlodion are used as containers and the process of making them is described.

5. The manner in which these capsules are exposed is explained.

6. A standard curve showing the relation between the amount of exposure and color change has been determined experimentally.

7. The solution can be sent by mail to any part of the country for exposure and returned to the laboratory for measurements.

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A COMPARISON OF PHOTOGRAPHIC AND IONIZATION MEASURES OF RADIATION QUALITY

By OTTO GLASSER, PH.D., *and* L. E. ROVNER, B.S., *Cleveland Clinic Foundation, Cleveland, Ohio*

I. THE PHOTOGRAPHIC DETERMINATION OF THE HALF VALUE LAYER

AMONG the many methods for obtaining a description of the quality, or absorption characteristics of a roentgen-ray beam, one that in recent years has gained more and more attention is the photographic determination of the half value layer. First suggested by the work of Christen (1), the Swiss mathematician and physician, and preceded by such devices as the Benoist penetrometer (2), the idea of a photographic method has been developed up to its present frequent use in roentgenology.

The half value layer describes roentgen radiation quality in terms of that thickness of an absorbing material, such as copper or aluminum, which reduces the incident intensity of a beam by 50 per cent.

Photographic determinations of the half value layer of a given roentgen-ray beam are ideally accomplished by the simple procedure of matching a photographic darkness, produced upon a film by a beam of half intensity, with the darkness under a metal filter stairs exposed to the full intensity of radiation.

There are several apparent recommendations for such a method of measurement: a group of intensity measurements can be obtained at one time; the film acts as a recording medium, yielding a permanent record of intensitites which may be expressed relatively by the film darkenings; the method is simple, and certainly it is inexpensive.

Meyer (3) has developed this process of half value layer measurements; his work also mentions the use of the stair filter with a 1.0 mm. copper strip to derive copper-aluminum equivalents photographically.

In the procedure generally followed, a suitable film or plate in a light-tight container is covered by a strip of lead, and by stair filters either of aluminum or copper, or both. This device is exposed to the roentgen-ray beam. At one-half the necessary exposure time, the beam is cut off, and the lead strip is removed without disturbing the stairs. The film is then exposed again for another interval of one-half time, so that the region under the stairs has received one full exposure, while that area under the lead has received one-half of the exposure.

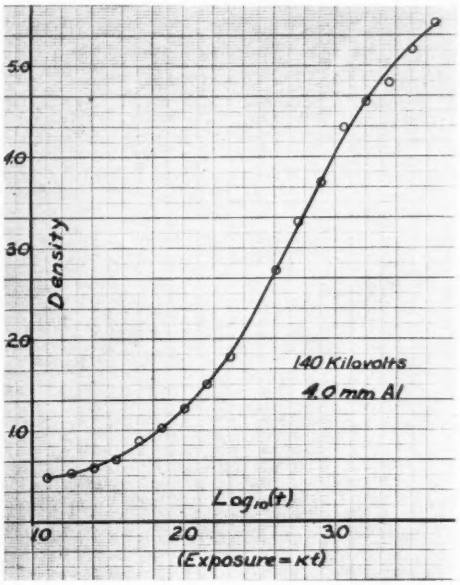

Fig. 1. Hurter and Driffield curve.

After proper development, those regions under the steps in which the photographic opacity is the same as that of the half-exposure-time strip are determined, and the step thicknesses corresponding to those areas are designated as half value layers.

It seemed worth while to make a study comparing the half value layers obtained

from photographic observation with those derived from the more generally accepted ionization absorption measurement of radiations produced by the same conditions.

additions in exposure time give less and less increase in the amount of reduction of the silver on the film.

The toe portion of the curve is defined

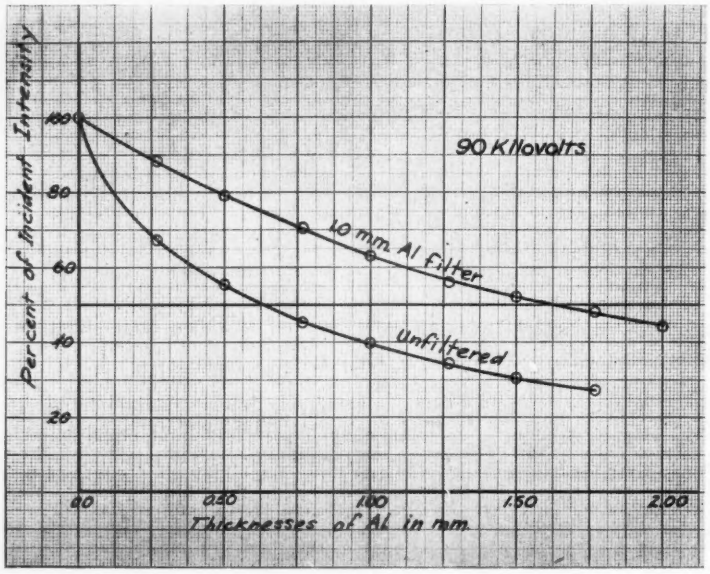

Fig. 2. Ionization absorption curves for 90 kilovolts.

II. RESPONSE OF THE PHOTOGRAPHIC EMULSION TO ROENTGEN RAYS

For measurements of any radiation by photographic methods, it is necessary to know the characteristics of response of the emulsion to the radiation. Such information is required in determining the relationship of radiation intensities to film darkening and in defining the limits of proper exposure.

The Hurter and Driffield curve for photographic emulsions (Fig. 1) describes their characteristics of action in response to actinic radiations on a time scale. From the curve it may be seen that increases in exposure time, with radiation of a fixed intensity, first produce only a gradual increase in the density of darkening on the film. Next, a uniformly increasing density occurs, following which a saturation value of the darkening is reached after which as the underexposed region; in the straight line interval the density is directly proportional to the logarithm of the exposure, and here conditions of correct exposure exist. (The slope of the straight line portion is a measure of the contrast of the lights and darks upon the emulsion.) Finally, densities occurring on the saturation arch are in the overexposed region.

For the Hurter and Driffield curve, photographic density is plotted against $\log_{10}$ of exposure; here the density of blackening of a film is defined as $\log_{10}\frac{i_o}{i_t}$. The quantity $\frac{i_o}{i_t}$ (the reciprocal of transmission, T) is the opacity, O, of a film, its darkness as seen to the eye; i_o and i_t are thus the incident and transmitted light intensities observed for an area of the developed emulsion.

The opacity of a film can be obtained from photometric measurements, and from this value the density is derived. In the case of an area allowing 1 per cent of incident light to pass, the transmission is then 1/100; the opacity, 100, and the density, $\log_{10} 100$, is 2.0.

The exposure, the quantity plotted as abscissa in the Hurter and Driffield curve, is described as the product of the intensity, I, and time, t, of application of the beam producing the darkness.

Until 1923 it was thought that the Hurter and Driffield curve for roentgen-ray action upon the photographic emulsion had no saturation value; it was assumed to be exponential throughout. At that time, Jones (4), of the Eastman Laboratories, produced a densitometer measuring densities as high as six. Studying the response of the process plate to x-rays, Jones obtained a typical Hurter and Driffield curve occurring at high densities.

An assumption that underlies the photo-

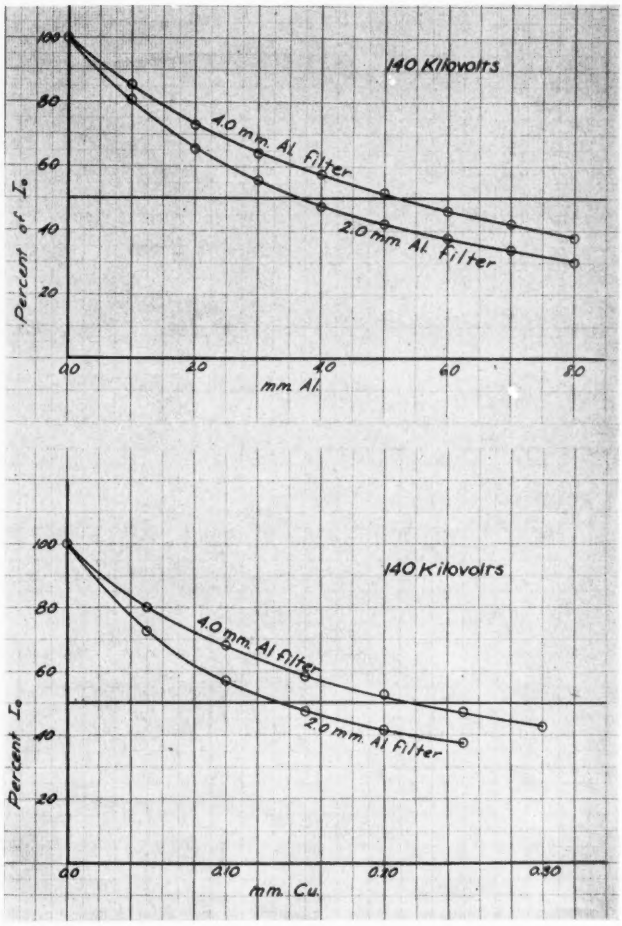

Fig. 3. (*Upper.*) Ionization absorption curves for 140 kilovolts.
Fig. 4. (*Lower.*) Ionization absorption curves for 140 kilovolts.

graphic determination of the half value layer is that the area exposed for one-half time will be as dark as though it were irradiated by x-rays of one-half the intensity: that is, $(^1/_2I) \times t = I \times (^1/_2t)$. This and similar relations are grouped under the reciprocity law, which is familiar to the biologist as the Bunsen-Roscoe law. The most general statement of this relationship is: $D = f(It^p)$.

It is easily seen that for these observations the value of the exponent p must be unity. The investigations of Glocker and Traub (5), and Bouwers (6) into the value of the constant p in the x-ray region give values approximating unity, that is $p = 0.98 \pm 0.01$ and $p = 0.99 \pm 0.02$, respectively. For a ratio of intensities within a range of 1 to 10, the deviation from the reciprocity law is less than 5 per cent. The constant, p, was assumed to be unity in interpreting the Hurter and Driffield curve.

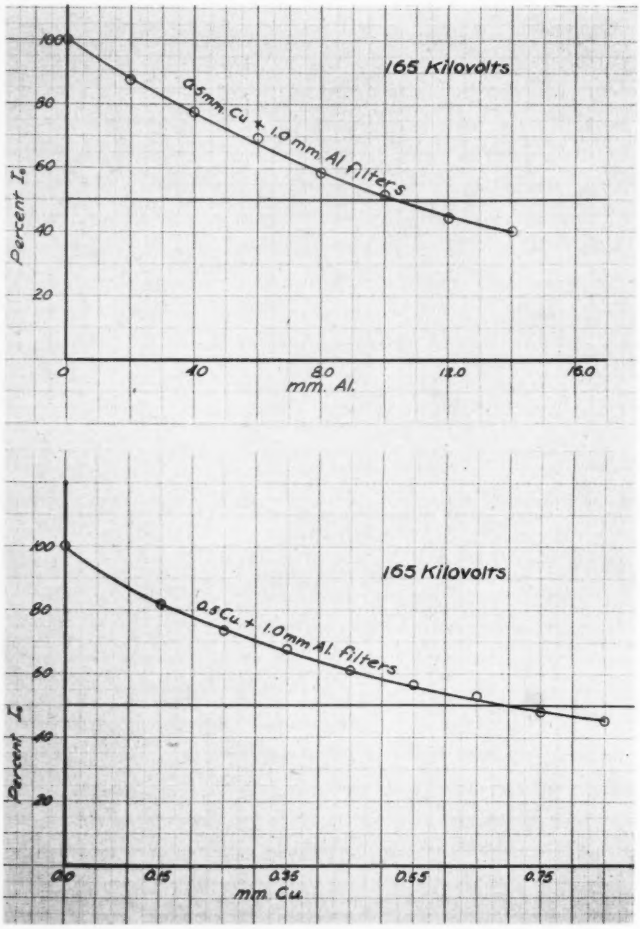

Fig. 5. (*Upper.*) Ionization absorption curves for 165 kilovolts.
Fig. 6. (*Lower.*) Ionization absorption curves for 165 kilovolts.

TABLE I

Condition	Kilovoltage	Filtration
1	90	None
2	90	1.0 mm. Al
3	140	2.0 mm. Al
4	140	4.0 mm. Al
5	165	0.5 mm. Cu + 1.0 mm. Al

(Tube current of 4.0 ma. throughout.)

TABLE II.—EXPOSURE TIMES

Condition	½ Time
1	30 sec.
2	1 min., 10 sec.
3	1 min., 10 sec.
4	1 min., 30 sec.
5	2 min., 15 sec.

III. APPARATUS AND EXPERIMENTAL PROCEDURE

In the process of the study, three distinct groups of equipment were used: x-ray, photographic, and densitometric.

A Westinghouse Quadrocondex apparatus was used to supply current to a 200-kilovolt Coolidge deep therapy tube. Intensity and absorption measures of the x-ray beam were made with a standard air ionization chamber described by Glasser (7) for the following five conditions commonly met in roentgen therapy (Table I):

At each of the five conditions, the ionization measurements were taken for a series of filtrations in order to obtain percentage intensity curves from which the half value layers were derived.

To bracket the photographic measures with a check upon the quality output of the x-ray tube, a series of ionization absorption measures was run before and after the group of photographic observations. Curves of the second series are shown in Figures 2, 3, 4, 5, and 6.

For the photographic operations, the Eastman 5 × 7 inch single coated, safety process film was chosen because of its slow action and high contrast obtainable. It was inclosed in the regular cardboard x-ray cassette from which the lead backing was removed to minimize secondary radiation (Fig. 7).

In the procedure, the cassette was placed in a special holder at a focal distance of one meter. To avoid scattered radiation, a system of lead diaphragms was so arranged that the beam swept through the cardboard and film without striking the carriage or film support (Fig. 8).

TABLE III[2]

	1.0 mm. Al Steps		0.1 mm. Cu Steps	
Step	Step density	H.V.D.	Step density	H.V.D.
1	2.37	2.07	2.32	2.17
2	2.30	2.08	2.12	2.19
3	2.22	2.10	1.93	2.17
4	2.13	2.13	1.77	2.15
5	2.11	2.12	1.64	2.13
6	2.04	2.16	1.53	2.13
7	2.00	2.18	1.43	2.14
8	1.96	2.18	1.32	2.10
9	1.91	2.17	1.21	2.06
10	1.87	2.20	1.13	2.06
11	1.78	2.20	....	....
12	2.17	2.17	....	....

[2] Measurements by Dr. Wilsey.

For developing the film, a large thermostat bath was set up, and specially prepared glass tubes were used as developing vessels, operated while immersed in the thermostat bath. The tubes were equipped with smooth glass pistons to provide a positive agitation of the developer about the emulsion. Also suspended in the thermostat bath were two large rubber tanks, one containing water, the other, the fixing solution.

The choice of a developer for accurate physical measurements of film darkening is restricted to that of a non-staining, low-fog-production type. Stain developers, such as pyrogallol, produce some of the blackening upon the film by their property of turning dark after oxidization in the development process. Since this stain darkening may be a variable factor, it is best to avoid such a type of developer.

An amidol developer was chosen because of its stainless developing property, its low-fog-production, and the ease with which it could be prepared from a stock mixture. Approximately 300 c.c. of full-strength developer was used for two films and then discarded. The fixing bath was of the usual acid hypo type.

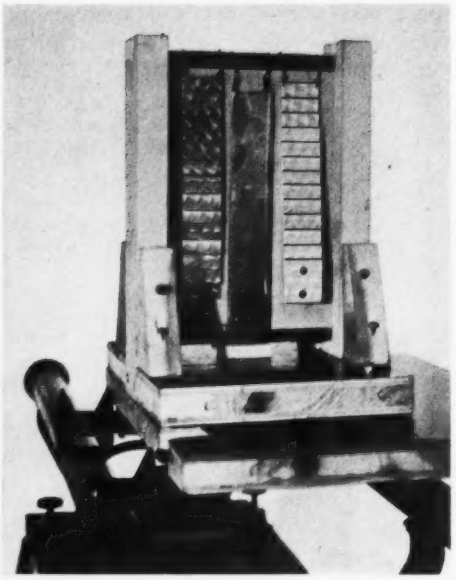

Fig. 7. Film and stairs for measuring absorption by photographic method.

Here another advantage of the amidol was that it was neutral chemically, so that films could be transferred from the developer directly into the acid hypo bath without an intermediate washing, and thus the time of development could be regulated more closely.

In preparing for the photographic measurements of the half value layer, data for Hurter and Driffield curves for each of the five conditions were first obtained. For each condition, areas of a single film were exposed to a beam held at constant intensity. The time intervals of exposure were increased in geometric progression by the ratio of the square root of 2. Timing was performed by a hand shutter and the focal distance was so arranged that a time interval of no less than twenty seconds was used on the straight-line portion of the curve.

After the Hurter and Driffield curves had been established, a trial exposure of the stair-bearing films was made under controlled conditions, and the times of exposure for the various filtrations were roughly determined so that the half value densities fell within the straight-line portion of the curve, the region of correct exposure. It was found that half-time exposures of between 5 r and 10 r gave the required results. In determining these exposure times the intensity of radiation directly within the cassette was measured with a thimble type chamber. The times required are shown in Table II.

After exposure, the films were developed in the thermostat tubes for five minutes at a temperature of 18° ± 0.2° C. (To observe the effect of temperature of development, one set of films was developed at 17° and another at 19°. Both sets gave results consistently different from those obtained at 18°.)

Before a film was placed in the developing tube, it was immersed in the water tray to change its temperature from that of the room to approximately the desired value. With the film in the tube, the developer was added and then stirred in a non-rhythmic fashion by the glass piston. This precaution was taken since positive agitation is necessary to produce uniform development, by keeping a temperature equilibrium, and by preventing a lowering of densities of film areas adjacent to high density regions. Rhythmic agitation of the developer may give rise to nodes of liquid motion in the tube and so produce banded regions of varying darkness along the film.

Despite the precautions used to obtain uniform development, the films were not uniformly darkened, possibly because of variations in the sensitivity or thickness of the emulsion.

It was found that the half-time strip, which should be of uniform density throughout, for the visual method of measurement outlined, varied in darkness along its length and introduced possibilities of error in measurement.

A comparison of densities of the half-time strip and those under the steps are shown in Table III.

In this case, the density of the half-time strip just opposite each step was taken down the whole length of the strip. The

possibility of error in a visual method, by comparing a step directly with only the adjacent half value density, is apparent.

To arrive at the best values of photographic half value layers, densitometer measurements were made giving an average of the half value density, and an interpolation was made from the intercept of this value with a curve of step densities plotted against step thicknesses.[1]

Greatest stress, however, was laid upon the use of direct visual comparison, as this is the method used in practice. Direct comparisons for the half value layer were made by placing the film upon a slit cut in dark paper covering a ground glass diffusing screen.

TABLE IV

Condition	Half Value Layers			
	Ionization		Photographic	
	Aluminum	Copper	Aluminum	Copper
1	0.63 mm.	...	$1.4\,^{1.5}_{1.4}$ mm.	....
2	1.60 mm.	...	$2.5\,^{2.8}_{2.4}$ mm.	....
3	3.67 mm.	0.136 mm.	$4.8\,^{5.5}_{4.5}$ mm.	0.20 mm.
4	5.23 mm.	0.231 mm.	$6.1\,^{6.5}_{5.5}$ mm.	0.24 mm.
5	10.4 mm.	0.666 mm.	$11.0\,^{11.5}_{9.5}$ mm.	0.52 mm.

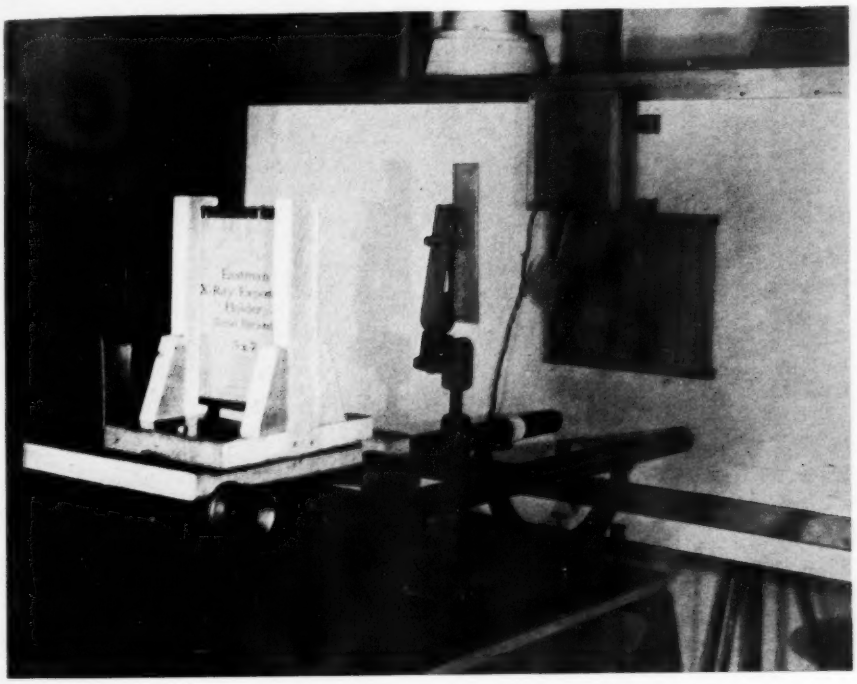

Fig. 8. Film and shutter arrangement for photographic method.

IV. EXPERIMENTAL RESULTS

The mean values for the half value layers obtained photographically are compared with those obtained by ionization methods in Table IV and in Figure 9.

In Table IV and the curves of Figure 9 only the aluminum half value layers are the result of eye comparison. Copper values shown are the average of the photometer readings alone, for the visual copper half value layers for conditions 3 and 4 in Table I were the same: 0.20 mm., since no interpolations were possible. The visual copper value for condition 4 is 0.54 millimeter.

[1] We are indebted to W. E. Forsythe, of the Nela Park Laboratories of Cleveland, Ohio, as well as to N. Rashevsky, of the Westinghouse Electric and Manufacturing Company Research Laboratories, Pittsburgh, Pa., M. J. M. Schwarzschild, of Beth Israel Hospital, New York, and R. B. Wilsey, of the Eastman Kodak Company Research Laboratories, Rochester, N. Y., for their kindness in making various density measurements of our films.

For aluminum, the table shows the greatest and least values of the half value layer observed for any one condition to the right of the mean value. A least squares solution of probable error, for the fourteen sets of observations taken, is impossible, since the half value layers observed photographically differed from each other by an integral number of metal steps or thicknesses.

The ionization half value layers shown are the averages of the two sets of absorption curves.

For the curves of Figure 9 the effective wave lengths were determined to two significant figures by the Duane single filter method. (The solid points on the curves were obtained on a Kelley-Koett mechanically rectified system, operating at higher kilovoltages, in an attempt to extend the curves to lower effective wave lengths.)

While the aluminum half value layer curves do not intersect, it is noted that with decreasing wave lengths the photographic copper half value layers are first less than, and then cross over to exceed the ionization values for the half value layer. Such a lack of parallelism would infer a relation between copper-aluminum intensity equivalents, taken photographically, that is different from the ionization copper-aluminum intensity equivalents. The effective wave lengths determined from the Duane equivalence curves, using

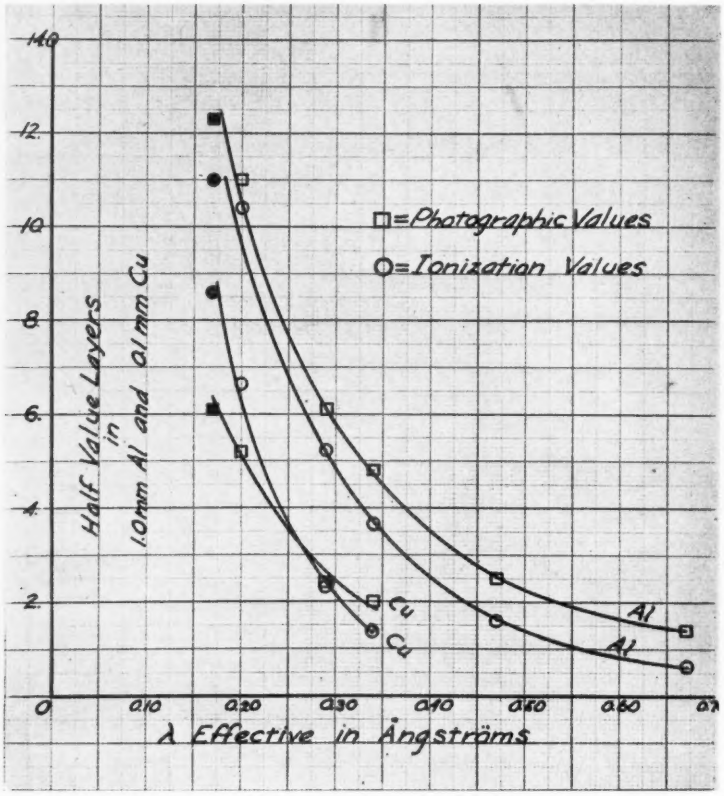

Fig. 9. Half value layer curves in copper and aluminum obtained photographically and by ionization.

photographic values would differ from those obtained by ionization. In other words, the values are modified by interposition of the photographic measuring method, which is essentially a transfer process, and which may introduce a variable factor of difference depending upon the responses of the film.

The higher values of the half value layer obtained photographically for aluminum in comparison with the ionization half value layer may possibly be attributed to secondary radiation from the metal steps. This radiation would increase the exposure under the steps, and consequently greater thicknesses of metal would be necessary to reduce the recorded density to that of the half value strip.

V. SUMMARY

1. A comparison of photographic and ionization measurements of half value layers has been made for types of roentgen radiations usually employed in therapy.

2. To determine correct exposures for the films in the photographic method, Hurter and Driffield response curves were obtained.

3. The films were exposed and developed by a uniform process.

4. The photographic values of the half value layers obtained were consistent with each other for a given condition of radiation.

5. The photographic values differed from those obtained by ionization methods by a variable factor, which permits no correction to be applied, and renders difficult the use of copper-aluminum photographic equivalents.

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A STUDY OF SOME PHYSIOLOGICAL EFFECTS OF ULTRA-VIOLET IRRADIATIONS UPON NORMAL ADULTS[1]

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From the Division of Home Economics, University of Minnesota, University Farm

A SURVEY of the literature, published in the last few years, reveals little information describing the effect of ultra-violet radiation upon the physiologic blood picture of normal healthy adults. Many apparently do receive benefit from such treatments, but efforts to explain the results have not thus far produced a great unanimity of opinion regarding their influence on ordinary clinical data. There also seems to be urgent need for standardization of dosage, since methods of measuring and administering the radiations vary widely and the most evident effect, erythema, differs for different individuals, as cited by Coulter and Smith (1), Russell (2), Stenstrom and Gaida (3), Lane and Rockwood (4), Goodman (5), Waller (6), and Maughan and Dye (7). The type of lamp, subject (human or animal), and experimental conditions reported, must be responsible in part, at least, for the apparently differing effects of ultra-violet irradiation upon red blood cells, white cells, hemoglobin, blood pressure, pulse, temperature, appetite, and general metabolism, as cited by Russell (2), Mayer (8), Koenigsfeld (9), Eichelberger (10), Mason and Mason (11). Licknit (12), on the basis of work reported, has suggested that the beneficial effects of irradiation were psychic, generally with some local effect on the musculature in increasing the capacity for physical work, while Backmund (13) and Laurens (14) believe the effect to be from photo-electric or photochemical products produced. Johnston (15) feels that its tonic effect, while not a cure-all, may well be recommended along with other treatments as massage, diet, etc.

The effects of irradiation upon infections of the upper respiratory tract have been variously reported by Arbuckle (16), Maughan and Smiley (17), Doull, Hardy, Clark, and Herman (18), Bull, Maughan, and Waring (19). Eidinow (20) finds that the effects of ultra-violet radiation on substances in the blood stream are not as marked as in other media. Contra-indicatory symptoms are pointed out by Troup (21). Mayer (8) believes that more information is necessary before irradiation may be prescribed by those unfamiliar with its use. The Council on Physical Therapy of the American Medical Association (22) suggests that the sunshine lamps, sold directly to the public, be so constructed that the radiant energy emitted shall approximate sunlight and that no curative claims shall be made by the producer. The Council is not convinced that human beings in health require the great amount of energy that many advertisements would advise, and believes that in every case a physician should first be consulted, before treatments are started.

In the present study, certain clinical data were noted from week to week, throughout the winter months of 1930-1931 and 1931-1932, with the object of observing the effect of ultra-violet radiation under normal conditions, the subjects being a group of college women at the University of Minnesota. Only one limitation was imposed, namely, that neither the control nor the irradiated group be allowed to take cod liver oil or other Vitamin D concentrate. By virtue of their occupations, it was felt that all subjects would receive slight but comparable amounts of direct sunlight during the experimental period. As, clinically, data are commonly recorded concerning the individual's weight, temperature, pulse, respirations, blood pressure, and blood counts, giving information

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[1] Paper No. 1188 of the Journal Series of the University of Minnesota Agricultural Experiment Station.

Data taken from the thesis submitted to the Graduate School of the University of Minnesota in partial fulfillment of the requirement for the Ph.D. degree.

about physical condition, these were the specific factors noted here, together with any additional information relative to the cal significance. It was the aim to make observations upon the subjects at the same time, on the same day of each week

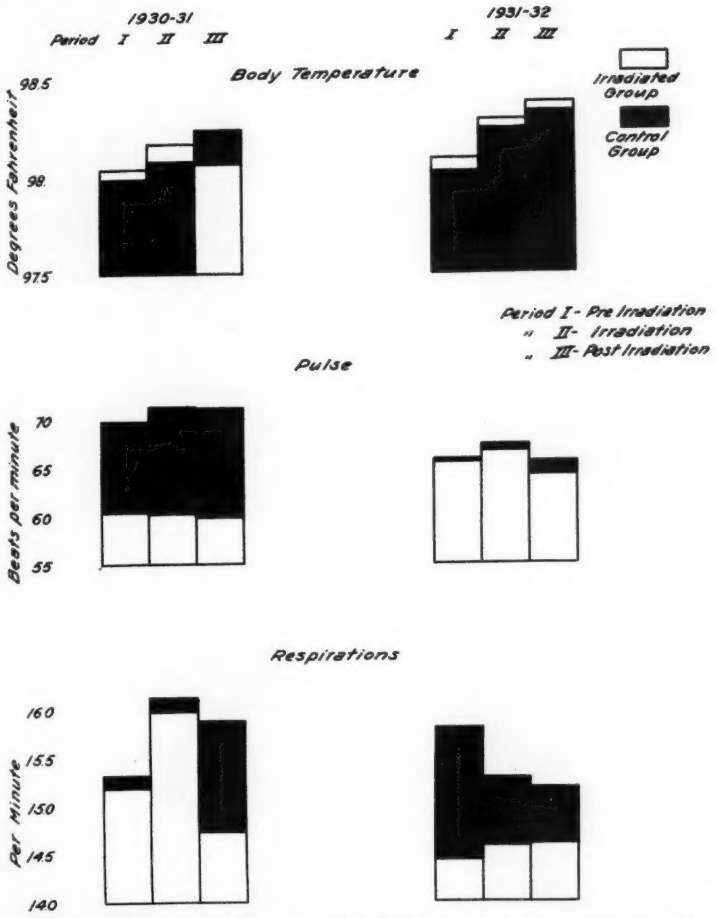

Fig. 1. A diagrammatic representation of the average body temperature, pulse rate, and respirations for the radiated and control groups during the three experimental periods, the pre-radiation, radiation, and post-radiation periods of 1930–1931 and 1931–1932.

number of colds in either the irradiated or the control group, and the effect of radiation on sleep, appetite, and physical efficiency.

EXPERIMENTAL WORK

It seemed advisable to keep the manipulations as simple as possible and at the same time an effort was made to choose methods which would yield results of clini- during the entire course of the experiment. This, however, was not always possible and, when necessary, the time of appointment was changed to a free hour close to the original one. The study was planned to cover the dark portion of the year, *i.e.*, that time when such of the sun's rays as reach the earth contain the smallest amount of therapeutically effective near-ultra-violet radiation, which, for the lati-

tude of the experiment, is the period from November to March. The time covered by the experiment was divided into three parts for each year: a preliminary four-weeks' observation period; an experimental period of several months, during which one-half the group (six subjects) received ultra-violet radiation, and a final observation period similar in length to the first, without radiation. The above-mentioned data were checked weekly, including total red and white and differential white counts and, in addition, the apparent effect of radiation upon the skin and the number of colds. Ultra-violet treatments were not interrupted during the menstrual period, the onset of menstruation being recorded in each case.

The age range of the groups was from 21 to 38 years. The personnel of the groups was chosen on the basis of histories taken. Appointments were arranged during morning and afternoon hours, never less than two hours after a meal, to avoid effects of digestion or excessive fatigue.[2] The weight

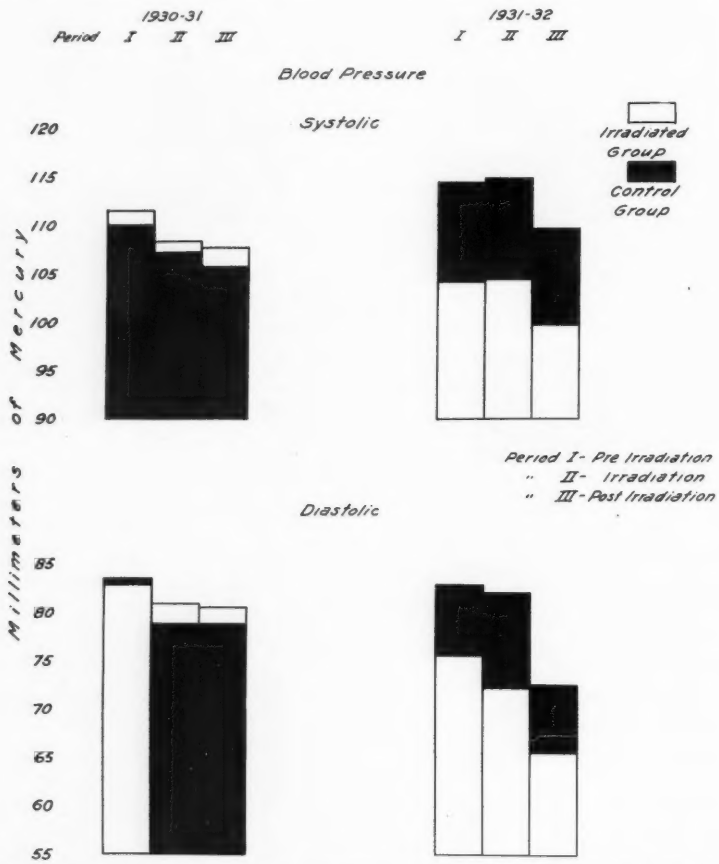

Fig. 2. A diagrammatic representation of the average systolic and diastolic blood pressures for the radiated and control groups during the three experimental periods, the pre-radiation, radiation, and post-radiation periods of 1930–1931 and 1931–1932.

[2] Since the preparation of this paper the following study has been reported: Lawrence, J. S., Stephens, D. J., and Jones, E.: Effect of Digestion on White Blood Cells. Am. Jour. Physiol., 1933, CVI, 309–313.

was taken before, and other observations and treatments made after, a twenty-minute rest period, while the subject was still prone. Standardized pipettes, thermometers, and counting chambers were used, the blood samples being taken from a spring lancet puncture in the ear lobes. Blood pressures were taken with a Becton-Dickenson portable mercury manometer, by the auscultatory method. Hemoglobin determinations were made by the use of the Sahli hemoglobinometer, with glass standards, and read with a daylight lamp.

The source of ultra-violet radiation was a new air-cooled mercury vapor arc lamp, with a Cooper-Hewitt Uviarc burner. This lamp was used only for this study during the two-year period and was tested from time to time by the zinc sulphide method of Janet Clark (23), to check the relative power of the lamp and its deterioration. No change was observed during the course of the experiment. The spectral emission curve, as reported by the manufacturer, indicated ultra-violet potency in the region of wave lengths 2,900–

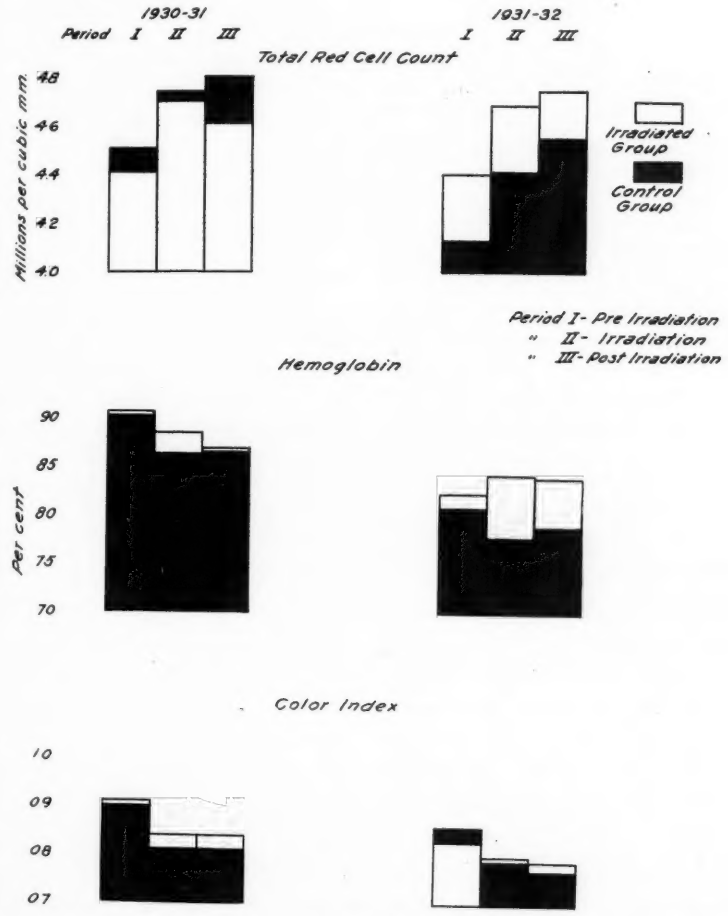

Fig. 3. A diagrammatic representation of the average total red cell count, hemoglobin, and color index for the radiated and control groups during the three experimental periods, the pre-radiation, radiation, and post-radiation periods of 1930–1931 and 1931–1932.

TABLE I.—RADIATION ADMINISTERED

1930–1931		1931–1932	
Subject	Amount received	Subject	Amount received
A	2 hrs. 29 min.	A	7 hrs. 4 min.
B	2 hrs. 17 min.	C	4 hrs. 2 min.
C	2 hrs. 17 min.	D	7 hrs. 34 min.
D	2 hrs. 35 min.	L	2 hrs. 42 min.
E	2 hrs. 15 min.	M	7 hrs. 21 min.
F	2 hrs. 17 min.	N	7 hrs. 34 min.
Total	14 hrs. 10 min.		36 hrs. 17 min.

3,150 Ångström units. The lamp was operated at 75 volts and 30 inches from the subject, the ventral and dorsal surfaces being exposed, with the burner directly over the trunk. The treatments were given as follows:

During the years 1930 and 1931 the subjects were irradiated once a week, the initial dose being one-half minute; the second, one minute, and each succeeding dose increased by one minute until a maximum of ten minutes, front and back, was reached. Two ten-minute treatments were given.

As the total amount of irradiation was relatively small the first year, the plan of dosage administered was somewhat altered and augmented during the second (Table I).

During the years 1931 and 1932, the subjects were irradiated twice a week, the initial dose being one-half minute, and each dose following increased by one-half minute, front and back, to ten minutes. The semi-weekly ten-minute irradiations were continued from three to four weeks, provided no discomfort was felt.

DISCUSSION

It will be seen that weather conditions during the two seasons were very similar (Table II). It is doubtful whether the slight difference in available sunshine materially influences the results, when one considers the winter clothing required and the occupation of the subjects. Since the tolerance of the different subjects was found to vary markedly the original schedule had to be varied somewhat to continue the suberythema dosage for each person, as cited by Buttolph (24) (Table I). The controls who wished it were given ultra-violet treatments at the end of the experiment each year, and in some cases subjects who belonged to the control group the first year became members of the radiated group the second.

Certain unexplained responses were noted. Subject L, not sensitive at the end of the first year to a moderate amount of ultra-violet radiation, seemed hypersensitive to the second, four months after an operation for the removal of an infected gall bladder. Subject T, a control the second year, three months after an emergency appendectomy, showed no sensitivity to radiation. Subject C felt no discomfort the first year, nor the second until after an attack of influenza, when she was decidedly sensitive for several weeks. At the end of the second series of treatments, this same subject had an apparent decrease in the clotting time of the samples for blood counts. She reported that her menstrual flow was more scanty and clotted than normal. The tendency of the menses to clot decreased after radiation was discontinued. No method was employed to measure pigmentation, but a moderate degree seemed to have been developed by the different members of the groups, as a result of the radiation.

Marked variations were evident in the individual data collected from week to week. It seemed advisable, therefore, to consider group behavior as a whole (Figs. 1, 2, 3, 4, 5, 6). The widest fluctuations in individual temperatures apparently occurred as a result of factors other than the radiation, as colds and influenza, the group averages showing no consistent effect attributable to the treatment given. A

TABLE II.—WEATHER REPORT

(U. S. Department of Agriculture, Weather Bureau, Minneapolis, Minn.)

1930–1931	Monthly mean temp., ° F.	Highest temp., ° F.	Lowest temp., ° F.	Sunshine percentage possible	Days, clear	Days, partly clear	Days, cloudy
October	48	86	21	51	7	9	15
November	37	68	− 4	59	9	6	15
December	23	45	−11	38	7	5	19
January	26	52	− 5	47	5	11	15
February	32	57	0	60	12	4	12
March	31	51	12	51	6	6	19
Average				51			
Totals					46	41	95
1931–1932							
October	54	81	38	53	13	4	14
November	40	68	12	39	7	8	15
December	30	48	− 1	35	7	6	18
January	18	42	−17	32	4	7	20
February	19	57	− 7	52	6	10	13
March	22	62	− 6	52	4	10	17
Average				43.8			
Totals					41	45	97

study of the pulse changes (Fig. 1) shows the behavior of the two control groups and the radiated group, 1931–1932, to be similar, with a difference between initial and final averages not greater than 1.5 beats per minute. These findings agree with those of Eichelberger (10), Paschetta (25), and Fries and Topper (26). The respiratory rate, too, seemed unaffected, since the difference between group averages from period to period was less than one per minute. It would seem probable that blood pressure variations (Fig. 2) were caused by such factors as fatigue and mental stress rather than radiation, as the control and irradiated groups behaved similarly. A difference in blood pressure at different times during the day was reported by Greisheimer, Merrill, and Lynch (27). It will be noted (Figs. 3 and 4) that the increases in the red cell count of the irradiated group (1931–1932), receiving nearly three times the total radiation of the group in 1930–1931, was similar to that of the two control groups. Thus it is apparent that, under these experimental conditions, ultra-violet radiations had little influence on the total red cell count. According to Spence (28), Furniss (29), and Russell (2) a different response is obtained in pathologic cases, in which the tendency under ultra-violet stimulation is to increase the red cell count toward the normal average figure.

The hemoglobin of the control groups (Figs. 3 and 4) behaved similarly and the general trend was much like that of the first year's radiated group. The radiated group the second year had a definitely higher average in the Spring than at the beginning of the observations in the preceding Fall. The increase was not gradual and maintained, but showed several peaks. The maximum ultra-violet dosage, reached and maintained from about the eighteenth or twentieth week to the twenty-second, did not keep the hemoglobin percentage above 85. The marked drop in hemoglobin, during the Christmas holiday and that in the later weeks of radiation (1931–1932), might result from a previous apparent rather than a real increase, due to the temporary mobilization of hemoglobin reserves from different parts of the body. The hemoglobin increases in the post-radiation periods may in some unidentified way be associated with seasonal factors or slight changes in general group activities.

Possibly also, for the purposes of stimulating hemoglobin formation, several short radiation periods, with breaks between them, are more effective than a continued treatment. Accepting 4,500,000 red cells per cubic millimeter as the normal for women, color indices fluctuated, but showed a general decline from Fall to Spring, followed by an increase. As Spence (28) found that the red cell count usually increased faster than the hemoglobin, it is possible to have a decreasing color index (Period 3, 1931-1932), while both red cells and hemoglobin are increasing.

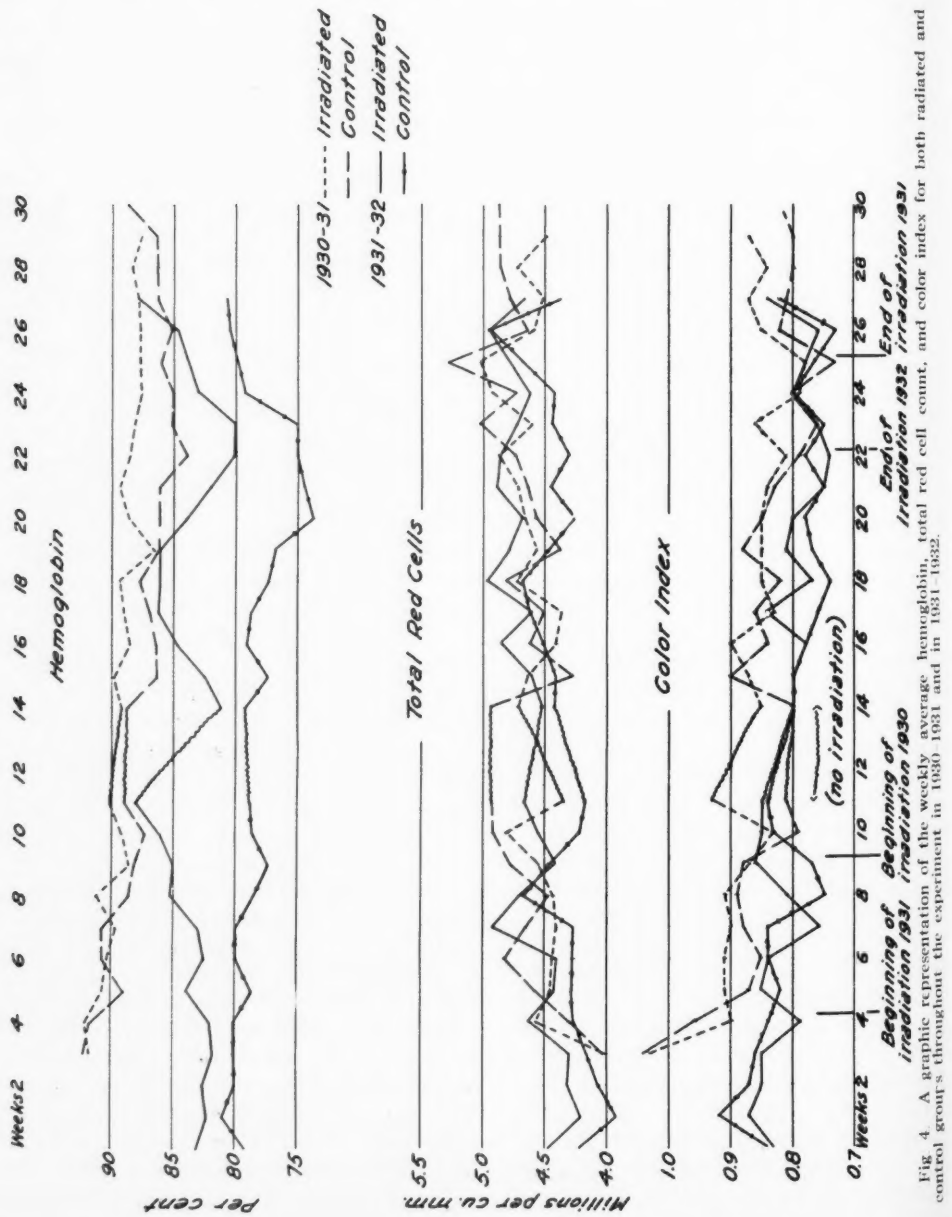

Fig. 4. A graphic representation of the weekly average hemoglobin, total red cell count, and color index for both radiated and control groups throughout the experiment in 1930-1931 and in 1931-1932.

In accordance with the work of Garrey and Butler (30), Ashmarin and Alekseo-Berkman (31), and Smith and McDowell (32), it would seem that irregularities observed in the total white cell counts were due to factors other than ultra-violet radiations, such as lack of physical or mental relaxation and infections (Fig. 5). The average differential counts for the control groups were similar both years, while the response of the radiated groups was reversed (Fig. 5), an increase in lymphocytes and a decrease in the percentage of polymorphonuclear cells having occurred during the administration of ultra-violet rays, the second year. The fluctuations of all four groups are fairly wide (Fig. 6), which makes the definite interpretation of any one variation rather difficult. The number of colds among the members of both control groups was the same, though the personnel differed (Table III). A decrease in total number of colds and estimated days of infection will be noted in the radiated group the second year. A greater number of cases of influenza occurred in 1931–1932, which would suggest that if ultra-violet rays, as administered,

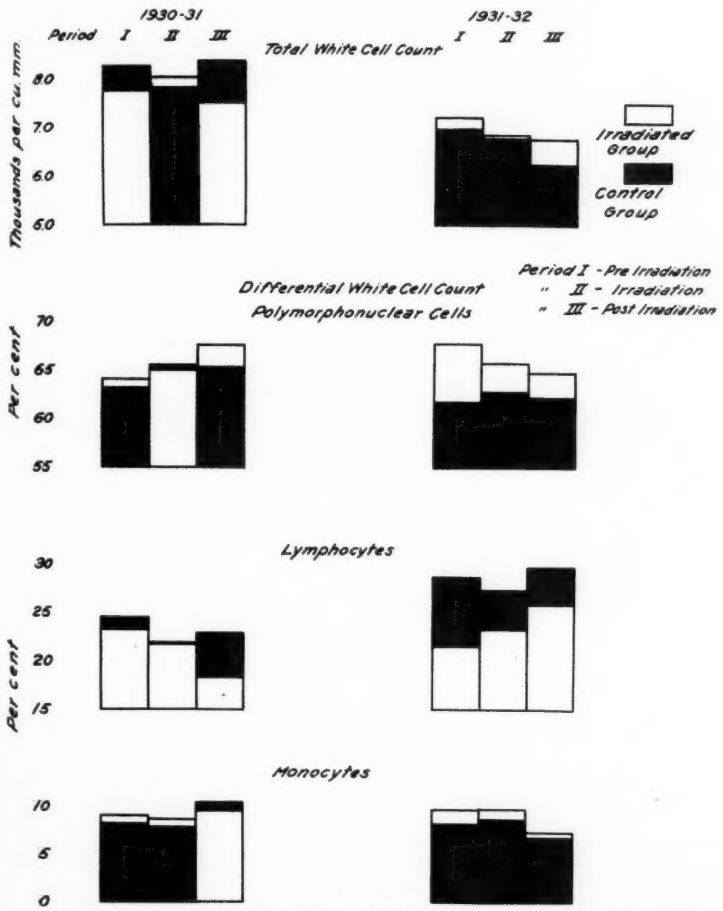

Fig. 5. A diagrammatic representation of the average total white cell and differential white cell counts for the radiated and control groups during the three experimental periods, the pre-radiation, radiation, and post-radiation periods of 1930–1931 and 1931–1932.

did have some beneficial effect in cold-prevention, the dosage was not effective in conferring immunity from influenza.

From any subjective observations within the scope of this study neither appetite nor sleep of the subjects was specially benefited, though two subjects reported that they "felt better" and their efficiency seemed to be improved during this period. In health, the human body has amazing powers of compensation, so that mild shocks of varying types may have little or

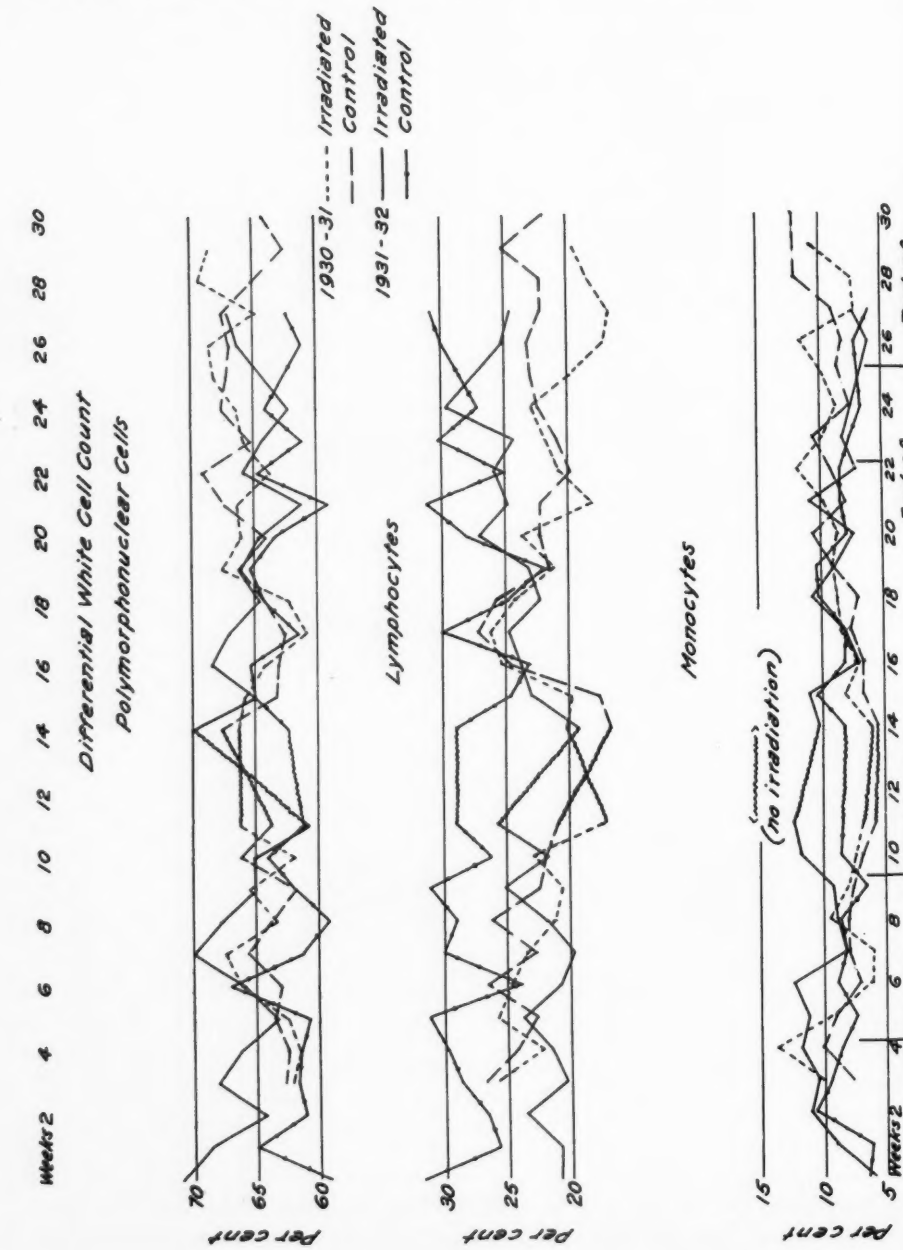

Fig. 6. A graphic representation of the weekly average percentage of polymorphonuclear cells, lymphocytes, and monocytes for both the radiated and control groups, throughout the experimental periods in 1930–1931 and 1931–1932.

TABLE III.—COLDS AND OTHER INFECTIONS

Subject	Number of colds	Days infected	Other infections
		Irradiated Group, 1930–1931	
A	3	13	None
B	3	12	Subject to chronic sinus infection
C	2	10	None
D	5	16	None
E	3	25	None
F	5	21	Subject to chronic sinus infection
Totals	21	97	
		Control Group, 1930–1931	
G	3	17	None
H	1	3	None
I	3	18	Influenza, 4 days
J	3	17	None
K	3	16	None
L	1	8	Quinsy, 4 days
Totals	14	79	Influenza and quinsy, 8 days
		Irradiated Group, 1931–1932	
A	1	4	Influenza, 5 days
C	0	0	Influenza, 21 days
D	1	4	None
L	1	2	Quinsy, 1 week; influenza, 3 weeks
M	4	16	None
N	1	5	None
Totals	8	31	Quinsy (7), influenza (47), 54 days
		Control Group, 1931–1932	
O	2	9	Influenza, 4 days
P	1	3	None
Q	3	21	Influenza, 3 days (subject to sinus infection)
R	4	18	None (chronic sinus infection)
S	4	11	Two light attacks of influenza, 6 days
T	0	0	None
Totals	14	62	Influenza, 13 days

no evident effect on the various body processes, and the apparent benefit resulting in many cases from ultra-violet treatments may certainly be psychologic rather than physiologic. Much remains to be explained regarding the salutory effects of such exposures for the average person, and conditions for and responses to treatments require further study before such treatments may be given indiscriminately. Future explanations of the results may be based on the further study of blood chemistry in the light of the behavior of such glands of internal secretion as the parathyroids.

SUMMARY

1. During the winter months of the years 1930–1931 and 1931–1932, two groups of healthy women were subjects for a study of the effect of ultra-violet radiation upon certain factors of clinical significance, such as temperature, pulse, respirations, blood counts, and blood pressure. The use of cod liver oil or other Vitamin D preparations was forbidden all subjects. One-half the group each year (six subjects) received ultra-violet radiation after the various weekly observations were made and blood samples taken. The control groups received no radiation during the experimental periods. During the second year (1931–1932) treatments were given twice, instead of once, a week and the subjects received approximately three times the amount of ultra-violet radiation as that given a similar group the preceding year.

2. Hemoglobin production appeared more pronouncedly affected the second

year than the first, though the effect did not continue indefinitely. It has not been determined whether this hemoglobin increase was real or apparent, due to the temporary mobilization of the hemoglobin reserves of the body.

3. The slight increase in the average total red cell count cannot be attributed to the effect of ultra-violet rays, as the control group behaved similarly.

4. The color indices of all groups decreased in a comparable manner from Fall to Spring.

5. Body temperature, pulse rate, and respirations appeared to fluctuate irrespective of ultra-violet irradiations.

6. Throughout the first experimental periods the average systolic and diastolic pressures of the control group showed a slightly greater decrease than that of the irradiated group. The second year the decreases were almost identical.

7. The total white counts appeared to be influenced less by ultra-violet rays than by other factors. During the first year the average percentage of polymorphonuclear cells of the radiated group increased and the lymphocytes decreased. The reverse was true during the second year.

8. With the greater amount of irradiation (1931–1932), the number of colds appeared to have been favorably influenced.

9. Irradiation, as here administered, produced no manifest effect upon appetite, weight, sleep, or physical efficiency of the group as a whole.

10. In general, ultra-violet radiation did not seem to influence type or regularity of menstrual flow. In one case only did there seem to be a decrease in blood-clotting time and in the amount of the menses.

11. The normal individual seems to have powers of compensation sufficiently great to counteract any stimulation resulting from ultra-violet radiation as administered in this study. Hence, in the various factors considered, the more nearly the person approached the physiologic norm, the less evident the effects from moderate ultra-violet treatments.

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X-RAY AND CATHODE RAY TUBES IN THE SERVICE OF BIOLOGY[1]

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From the Research Laboratory of the General Electric Company

SINCE the development of the hot cathode x-ray and the high voltage cathode ray tube such manifold and far-reaching uses for x-rays and cathode rays in the service of humanity have been uncovered that the mere mention of most of them simply constitutes a repetition of what has already become universally well known. To introduce the use of the x-ray in general and dental surgery, in cancer research, or in its thousand and one industrial applications, is excusable only on the basis of extended knowledge and experience in each field and the presentation of original detail.

There is one application of x-rays and cathode rays, however, of which we should like to say a few words. It is rather new, and, on the whole, not particularly well-known in general. Its future possibilities may be great, and, whether they be great or small, they must concern us as individuals in an unusually vital way. We refer to the alteration of hereditary traits and the creation of new varieties in plants and animals through the alteration and deformation of cell chromatin under x-ray and cathode-ray bombardment.

It is curious that, although adequate realization of the potentialities of x-rays and cathode rays in the alteration of cell chromatin and the production of heritable variations has been quite recent, and all of the best work dates from later years, the first experimental work in the field was undertaken at an early date—early on the scale to which most of our present-day creative work is set. As early as 1899 Lopriori, using a cold cathode x-ray tube, worked with *Vallisneria*, *Genista*, and *Darlingtonia*. His results, though positive, were not especially significant, whether by interpretation or by actual deficiency cannot be told. Perthes, in 1904, working with the ova of the worm *Ascaris*, demonstrated a marked retardation of cell division in irradiated material, and in the same year Gilman and Baetjer produced acceleration of embryologic development, deformation of embryos, and abnormal larvæ by the irradiation of ova of the salamander *Ambystoma*. The same workers later produced abnormal young chicks from x-rayed hens' eggs.

Attempts to apply results such as these followed very quickly, but they were clearly premature, and for the most part were not fruitful. Bordier, working with silkworms, produced only destructive results, as did Hasebroeck with related larvæ, though Hastings, Beckton, and Wedd claimed an acceleration of embryologic development. Some work was also done during this period on the problem of the effect of x-rays upon leukocyte production in the blood, upon which so much excellent work has been done within recent years. Benjamin, Reuss, Sleuka, and Schwartz, Aubertin and Beaujard, and Murphy and Norton all claimed stimulation—a verdict which might be less simply interpreted to-day.

The first especially notable morphologic work on the effect of the x-raying of seeds upon the subsequent growth of the seedlings was probably that done on sunflowers, tomatoes, and cosmos by Dr. E. L. Johnson, in 1926. Applying the E-unit of dosage (representing the radiation received by an object at 30 cm. focal distance, with a 5 cm. portal of entry from a hot cathode tube operated at 60 K.V.P. and 6 ma., with no filter), Johnson found a marked difference in the effect on wet and dry seeds, the latter being much more resistant to total inactivation, and also to

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

mutational effects. Some extraordinary aberrations appeared in seedlings from x-rayed seeds—ribbon-shaped stems, increased branching, dwarfing, doubled leaves and flowers, a shorter period from planting to flowering, and an initial decrease, followed by a marked increase, in the growth rate were all among the results secured.

Gager and Blakeslee, in 1927, reported similar experiments with *Datura*. Seeds exposed to radium beta radiation gave rise to a number of mutant types, characterized by differing form of flowers and leaves. Johnson continued her work on sunflowers in 1928, with results confirmatory of the earlier reports.

Early in the same year, Goodspeed and Olsen reported the beginning of a series of remarkable researches on the effect of x-rays on the growth and quality of the tobacco plant, using a hot cathode tube with air-cooled tungsten target, operated at 50 K.V.P. and 2.8 milliamperes. Over one thousand plants were grown with seed fertilized with x-rayed pollen, and of these 20 per cent on the average represented new variants. In one batch, 136 out of 168 plants were of new types. Dwarf, low, and tall varieties appeared, varieties with large leaves or small leaves, dark bottle-green leaves or light gray-green leaves, tough leaves or tender leaves, light pink, pink, or purple-red flowers. The wealth of cytologic material which these variants presented was such as to make a complete investigation of it extremely difficult.

Concurrently with Goodspeed and Olsen, L. J. Stadler reported effects of x-rays on maize and barley, resulting in the production of mosaic corn, and white, vine-shaped, variegated and other striking types of barley—results which have initiated much excellent work since. McKay and Goodspeed similarly conducted work on cotton, producing many conspicuous variants. One of the most interesting of these bore bolls in which the seed was free of the lint, while in another, giant seeds were produced. An extension of the cotton work was made public in June, 1931, by Horlacher and Killough, who produced a variety of creeping stock, changes in the shape of the leaves, remarkable color varieties, and other abnormalities.

Most of these workers, and many others of whom lack of time forbids mention, conducted a certain amount of cytologic work on x-rayed material, and found extraordinarily interesting chromosome abnormalities resulting from the treatment, even in stock appearing morphologically unchanged. J. W. Mavor was the first to discover the fact that chromosomal abnormalities of a very striking character appear consistently in a high percentage of x-rayed organisms. Using *Drosophila* as his material, he succeeded in demonstrating deletion, non-disjunction, and attachments of various kinds in germinal cells, in which entire fragments of chromosomes might be broken and destroyed or attached elsewhere, and the elimination of an entire sex-chromosome. H. J. Muller, in Texas, in 1927, first demonstrated actual single-locus mutations in x-rayed stock of *Drosophila*, and his work has since become classic. The rate of mutation among progeny of irradiated flies in some of Muller's experiments was 15,000 per cent greater than among the controls. Other workers in the same field have become too numerous to name individually, but their results are nearly all in substantial agreement with those of Mavor and Muller in indicating the extraordinary fertility with which mutations are produced in x-rayed material. Anderson, Babcock and Collins, Barth, Congdon, Demerec and Farrow, Dobzhansky, Hanson and Heys, Hanson and Winkelman, Harris, Hussey, Painter, Patterson, Serebrovsky, and Timofeef-Ressovsky, to mention only a few, have all reported extraordinarily interesting findings with the fruit fly.

Other workers have applied similar methods to cytological work in other organisms, including some at present of economic importance. Whiting's work with induced mutations in the wasp *Habrobracon*, Little and Bagg's with mice, and Curtis' with *Planaria* are too generally

well known to require elucidation, but they are extremely significant in indicating the extent of the possibilities to-day in carefully controlled biophysical genetics.

It was with such a background as we have roughly, briefly, and incompletely sketched that, a year ago, our Laboratory became interested in this field and has attempted to contribute to it. We are going to outline briefly the types of problems upon which we have been engaged, to mention such few results as we have yet achieved, and to indicate, above all, what our hope for future work is, and what is our concept of the sort of help that a physical laboratory can be in dealing with biologic problems of this character.

Our ignorance at the beginning of our work compelled us to make it entirely morphologic in nature, and further forced us to do a great deal which was of a purely elementary character in the determination of tolerances for different materials, which were found to vary widely. Bulbs, seeds, pollen, and buds of a wide range of plant material were x-rayed, cultivated, and carefully watched for evidences of mutational changes. In order that this work, crude though it was, should yet constitute some contribution to knowledge, we worked largely with 200 K.V. tungsten radiation, since the bulk of work has been done at lower voltages. Chromosome constitution was little considered in this early work, while economic importance was a controlling factor. A considerable number of mutational results of some interest were secured in citrus fruits, narcissi, gladiolus, and the lilies, and a number of crop plants. Cytologic analyses of the most interesting of these will be made during the coming winter.

We next worked from a more purely genetic standpoint with genetically controlled material. We became interested in following the course of a heterozygote containing one or more recessive factors in rather large x-rayed populations. Thus in crossing two of Ferguson's petunia stocks, kindly given us by Dr. Dale, of Union College, one containing a recessive for "stippling," the other for "variegation"—conditions represented respectively by numbers of colorless individual cells in the petal tissue and by large groups of colorless, air-filled cells—the first generation should normally be non-stippled, non-variegated, since both characters are recessive and they are non-allomorphic. In large populations of x-rayed seed, however, a certain percentage of the seedlings were found to exhibit the character "variegated" although this effect did not once appear in more than 500 controls—a result presumably due to x-ray inactivation of the dominant, allelomorphic, normal chromosome locus. A similar experiment is being carried forward with large populations of a type of sorghum heterozygous for albinism, kindly presented us by Dr. R. E. Karper, of Texas, who first discovered the condition as a head mutation.

In another interesting experimental program now in course of development, we have found it possible to produce, in a petunia stock of known chromosome constitution, a definite somatic color mutation with a definite quantity of x-ray energy. The mutation is reproducible, as we have proved on several occasions that it proceeds through a definite cycle in succeeding flowers of the affected plant, but can be kept constant by re-irradiation at proper intervals. There is some indication that it is specific, within wide limits, for energy inputs. Whether or not it may be germinal, we do not at present know.

We have entered the field of x-ray animal genetics in controlled material with the little killifish *Lebistes reticulatus*, in an investigation of x-ray induced changes in the male sex chromosome. The guppyi, we believe, will prove peculiarly suitable for this work, since the careful researches of Ojvind Winge, at Copenhagen, have indicated very definitely that in *Lebistes* the Y-chromosome is well filled with determinants of color in the male and, therefore, presents opportunities for analysis unobtainable with *Drosophila*.

Cytologic investigations are in progress at the moment in connection with the

Laboratory concerning changes brought about in the spiral chromonema within the chromosome in pollen mother cells of *Tradescantia* exposed to various wave lengths of x-rays and to cathode-ray bombardment.

On the more analytical side, we have become extremely interested in the inhibitive effects of x-rays and cathode rays on growth in single cells, the material used at the moment being pollen grains of the *Liliacæ* and spores of the mold *Penicillium*. The output of a cathode-ray tube has been measured in roentgens, and a comparative study of the relative effect on the survival ratio of equivalent energy inputs of x-rays and cathode rays is in progress, leading to the interesting provisional conclusion that different energy inputs may be required to produce equivalent survival ratios in the same material. Confirmation of such a result and its explanation remains for the future.

We plan to undertake some investigative work in a number of related fields which seem of interest and promise, and in which we hope that we can be of some service as contributors, as soon as time and facilities are available. Such fields, of course, abound, and careful selection, as everywhere, is necessary here. Data are badly needed in the field of the genetic effect of secondary x-radiation set up within the tissues as in secondary x-ray cancer therapy. We hope to undertake work in the field rather soon, using perfused *Drosophila* larvæ as material. Studies of the alteration of the sex ratio at the point of lethal limit of viability for one gamete are very desirable, especially with dioeceous plants, in which they may well contribute to knowledge of the now little understood mechanism of sex determination in such organisms. Work has been begun in this field, using the strictly dioeceous hemp as material. Studies in radiation effects in the so-called bacteria-bacteriophage "conjugations" seem extremely desirable, and work of this character has been begun in Schenectady by one who, though not in the Laboratory, enjoys its facilities.

It is our hope and belief that, in the future, we may make some real contribution to progress in the field of radiation genetics and kindred effects. We believe that we stand in a position, by reason of the unusual physical facilities in x-ray and cathode-ray tubes and the unusual wealth of physical information at our command, to perform a real service to biophysical science, to some extent in prosecuting biophysical work ourselves which will be carried through to the best of our ability, and to a greater extent in the initiation of and the assistance in work elsewhere in this, clearly one of the most significant of the frontiers of modern scientific investigation.

PNEUMOPERICARDIUM FOLLOWING A FOREIGN BODY IN THE ESOPHAGUS[1]

By ROBERT A. ARENS, M.D., *and* ELLEN STEWART, M.D., *Chicago, Illinois*

Radiologist and Fellow in Radiology, Respectively, Michael Reese Hospital

PNEUMOPERICARDIUM was first described by Bricheteau in 1844, and his diagnosis was confirmed by the autopsy findings. James (1903) reviewed 38 cases of pneumopericardium, while Gottesman and Bendick (1926) added seven more. The writers have been able to find four other cases in the literature, those of Arrernes (1926), Leys (1926), Molnar (1927), and Imperatori (1928), which make a total of 49 cases. A few of the foregoing cases are the result of spontaneous gas production from infected pericardial fluid, but the majority of them are the result of traumatic perforation of the pericardium from within or from without, of perforation into the pericardium from a neighboring organ, or the perforation of a diseased pericardium into a neighboring organ.

Pneumopericardium in man, resulting from a perforation of the esophagus due to a foreign body, however, is found less frequently than either pneumopericardium due to penetration of a foreign body through the chest wall, or to a contusion of the thorax. Pneumopericardium in animals, resulting from perforation of the esophagus by a foreign body, is a frequent

[1] Read before the Section on Radiology, Illinois State Medical Society, Springfield, May 18, 1932.

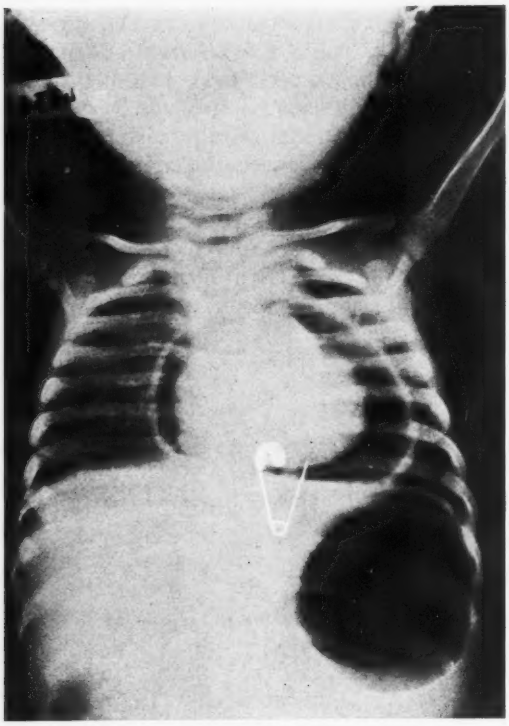

Fig. 1-*A*. Anteroposterior projection showing pneumopericardium with open safety pin *in situ*. Note the thickness of the pericardial sac.

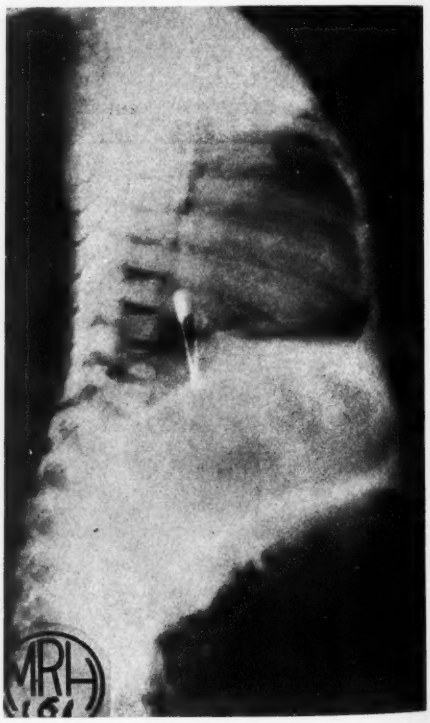

Fig. 1-*B*. Lateral projection of same case shown in Fig. 1-*A*.

finding. Imperatori mentions that numerous cases are found in monkeys, induced by biting off and swallowing pieces of barbed wire from their inclosures. Brailsford (1929) also states that it is commonly found in cattle sent to the public abattoir, due to swallowing long strips of sharp metal or wire.

Only four cases of pneumopericardium resulting from foreign bodies in the esophagus have been noted in the literature by the writers. All of these ended fatally. Buist (1839) reported a case of pneumopericardium in an adult, the result of swallowing a dental plate. This condition, however, was not recognized during life, but was found at autopsy fourteen days later. Walsh (1873) reported pneumopericardium from an esophageal wound due to swallowing a sword, which was diagnosed during life, while James (1904) cited a case of pneumopericardium in a girl 25 years of age, resulting from a sliver of bone perforating the esophagus. This was diagnosed during life, and at autopsy ten days later two oval openings were found in the esophagus, each 2 cm. in length, directly opposite each other, one of which perforated the pericardium. In 1928, Imperatori reported a case similar to ours, in an infant 13 months of age, who swallowed an open safety pin. An autopsy revealed a pericardial-esophageal fistula.

Clinical History.—W. M., eight-months-old infant, entered the Sarah Morris Hospital, service of Dr. Jesse R. Gerstley, May 22, 1928. A cough which had developed five days previous to entrance, was the chief complaint made by the mother at the time of admission.

The following history was also obtained: The child had been well until, five months before hospitalization, when there was bleeding from the bowel for a day, followed by tarry stools. The passage of bright red blood was seen one month later, this as before being followed by the passage of tarry stools. At this time the mother had found the baby "blue, stiff, and seemingly dead" for several minutes. Since then there had been difficulty in swallowing, an anorexia, and a loss of weight.

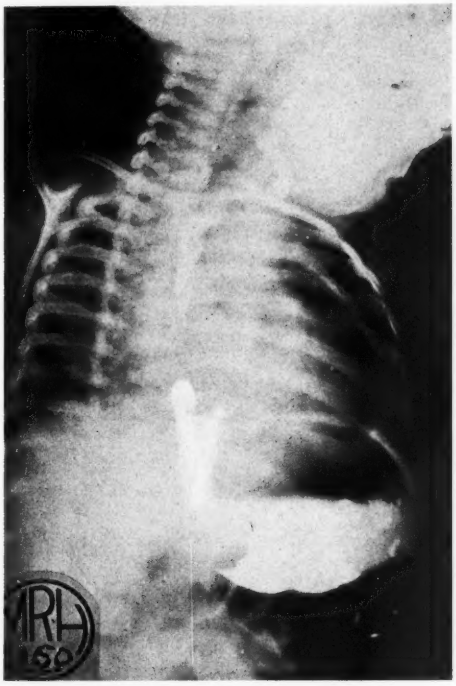

Fig. 2. Right oblique projection showing pneumopericardium with barium-filled esophagus and open safety pin at about the level of the esophageal hiatus. Note the barium at point of pin and free communication into the pericardium.

Physical examination on admission showed an undernourished white child of eight months, with moderate beading of the costochondral articulations. There was some impairment of resonance in the left base posteriorly, with the lung fields elsewhere negative. The abdomen was flabby and distended. The liver was firm, extending 4 cm. below the right costal margin. The tentative diagnosis was a rachitis of moderate degree, a mild pharyngitis, and a resolving left lobar pneumonia.

A roentgenogram, taken because of the probable pneumonia, revealed a pneumopericardium, with an open safety pin lying in the esophagus between the seventh and tenth ribs posteriorly. The open end was up and the closed end was at the cardia of the stomach (Figs. 1-*A* and 1-*B*).

There was an area of increased density in the upper left lung field, suggestive of pneumonia. This finding, however, was not definite (Fig. 1-*A*).

A barium meal, given the same day, showed the barium-filled esophagus with the open safety pin at the level of the esophageal hiatus in the diaphragm. Barium was also seen to enter the fistulous tract into the pericardium (Fig. 2).

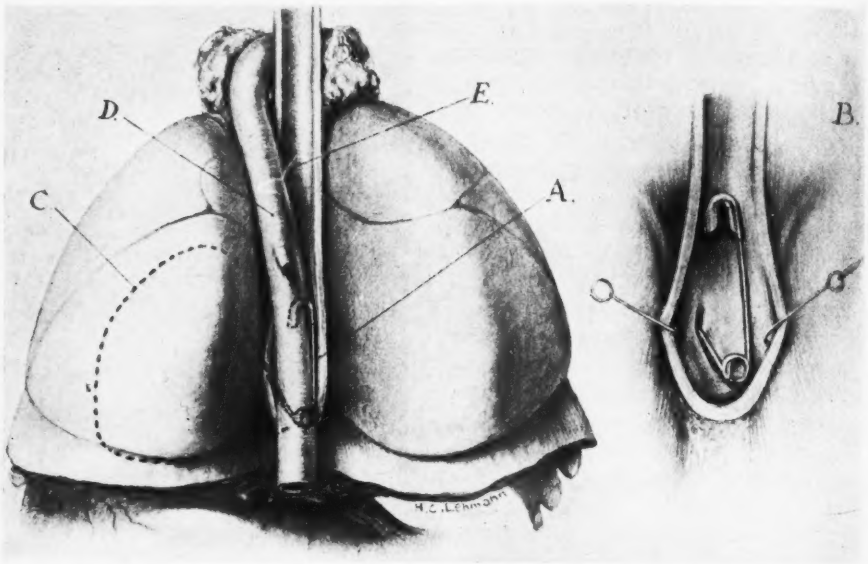

Fig. 3. Drawing of autopsy specimen: (*A*) Open safety pin in esophagus, with pointed branch penetrating into pericardium; (*B*) Drawing showing the fistulous tract through the esophageal wall; (*C*) Outline of pericardial sac; (*D*) Thoracic aorta; (*E*) Esophagus.

The following day an esophagoscope was passed and an unsuccessful attempt made to dislodge the pin. Roentgenograms showed that the position of the pin had not changed. The child's temperature, which had varied between 101° and 103° F. dropped to 98.6° F. The next day, May 27, 1928, vomiting became projectile, there was marked difficulty in breathing, and the child died.

Autopsy Report.—The pericardial sac contained 100 c.c. of cloudy purulent fluid. The visceral surface of the pericardium was covered by a layer of fibrin. Upon opening the esophagus from its posterior aspect, at the lowest portion, a safety pin was found in the lumen, the bend resting at the point where the esophagus passes through the diaphragm. The pointed end of the erect safety pin had perforated the anterior portion of the esophagus, extending to the left, upward and anteriorly, and had passed through the mediastinal tissue, with 5 mm. of the point lying in a groove on the surface of the heart. The pin had produced a fistula which connected the pericardial cavity and the esophagus (Fig. 4). On the surface of the left lung there were several dark areas, non-crepitant and firm. The diagnosis made from the above findings was: "Subacute purulent pericarditis. Sinus tract from the pericardial cavity to the esophagus, formed by safety pin in the esophagus."

Discussion.—The symptoms of pneumopericardium, according to Rigler (1925), are variable and depend entirely upon the etiology. There are two outstanding symptoms—precordial pain and attacks of dyspnea. The signs, however, are con-

stant and unmistakable. On percussion, normal pericardial dullness is replaced by a shifting area of tympany over the precordium. On auscultation, there is a splashing, gurgling, churning sound, the "brûit de moulin," resembling the noise made by a water wheel and synchronous with the heart beat. The heart sounds are diminished. Herschfelder (1918) stated that the percussion note over the cardiac area may vary from bell-like tympany to absolute wooden flatness, and when the opening into the pericardium is of medium size a "cracked-pot" note may be heard. The roentgenogram, however, is the most positive sign and confirms the diagnosis. According to Brailsford (1929), pneumopericardium is rarely diagnosed during life. It may exist, yet its presence may be unsuspected owing to the insidious development during the progress of a grave lesion, or to the fact that the symptoms and physical signs in the primary lesion mask those of this condition.

In cases of pneumopericardium following a foreign body in the esophagus, reported by Walsh and James, the diagnosis was made from the signs of shifting dullness and tympany, together with the characteristic "water-wheel murmur." The case reported by Buist was not recognized during life. No characteristic signs or symptoms were noted in the case reported by Imperatori, the diagnosis being made from the radiograms alone.

In our case there was no history of the child having swallowed a foreign body, not an unusual finding, for infants are seldom seen in the act of swallowing foreign bodies. Foreign bodies, including open safety pins, can be swallowed and remain in the esophagus for from one to five months, and produce no symptoms warranting hospitalization until an advanced pathologic process has been reached. This occurred in our case and also in the similar case of pneumopericardium reported by Imperatori. Two other cases, showing safety pins lodged in the esophagi of children for a month, unsuspected, were also mentioned by Imperatori.

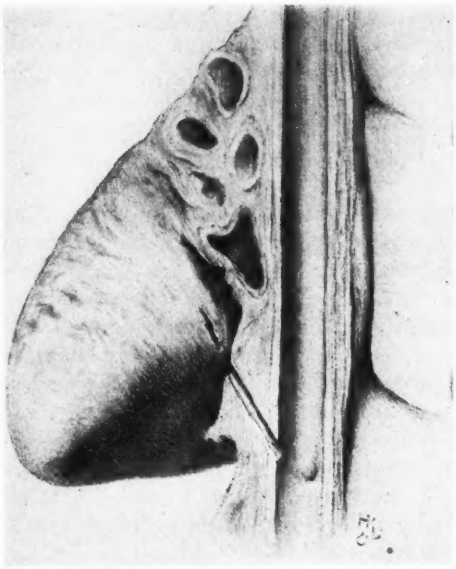

Fig. 4. Drawing of autopsy specimen of the heart showing fistulous tract, the result of the pointed branch of the open safety pin penetrating the walls of the esophagus into the pericardium.

The presence of bright red blood in the stools, followed by tarry stools, while of grave medical significance, did not cause the mother to seek medical attention for the child. The quantity of blood, too, must have been large, to have given such findings and its presence can be accounted for only by the fact that the pin punctured the wall of the esophagus. The recurrence of blood one month later may be explained by the vomiting, sufficient to produce reverse peristalsis in the esophagus and to break the adhesions which possibly had been formed around the pin.

There was, also, a history of an attack of cyanosis, followed by syncopy. The cyanosis, no doubt, was due to embarrassed heart action, resulting from the air in the pericardium. Impaired resonance over the left base posteriorly may be accounted for by the pressure on the lung by the dilated pericardial sac.

The water-wheel murmur expected in pneumopericardium could not be elicited. Whether or not this was due to the prone position of the child at the time of the

examination, the distribution of fluid in the pericardial sac, or the pressure of the greatly dilated stomach against the pericardium, cannot be determined.

CONCLUSIONS

Reported cases of pneumopericardium following a foreign body in the esophagus are very rare—only four cases were noted in the literature by the writers. Three of these were in adults. In infants this condition is even more rare, only one other case having been found. It is probable that the condition is not actually so rare as it appears, since the symptoms and signs are indefinite and often misleading, and are usually diagnosed only from the roentgenologic or autopsy findings. In this case the diagnosis was made from the roentgenograms, confirmed by the findings at autopsy.

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BRONCHIAL OBSTRUCTION: ITS DIAGNOSIS AND TREATMENT[1]

By ROLLIN H. STEVENS, M.D., *and* WILLIAM A. HUDSON, M.D., *Detroit*

BRONCHIAL obstruction is a condition that presents a group of clinical, physical, and roentgenologic findings which appear in a definite sequence, the nature of the finding at any given time being dependent upon the period in the development of the obstruction at the time the condition is being studied. The etiologic factors are varied and numerous, but all may produce some similar changes at corresponding stages in the development of a bronchial obstruction. The cause of the obstruction may lie wholly within the lumen of a bronchus, as in the case of an intrabronchial foreign body; it may originate within the bronchial wall, as in the case of a bronchogenic carcinoma, or it may lie entirely outside the wall of the bronchus in the peribronchial or adjacent tissue, as in the case of an aneurysm, causing compression and obstruction of a bronchus.

There have appeared in the literature numerous articles dealing with bronchial obstructions. For the most part, these articles have dealt with some particular type of obstruction, such as foreign bodies in the tracheobronchial tree, or carcinoma of the bronchus, or they have dealt with some condition which has developed secondarily to the obstruction, such as a massive atelectasia or a drowned lung.

For some time we have directed our thoughts toward bronchial obstruction as an anatomic and physiologic condition rather than toward the etiologic factor or the secondary changes. We have felt that it should be possible to arrive at some general principles which might be of primary importance in establishing a diagnosis of bronchial obstruction in any and all cases of obstructive lesions encountered, and that, having such general principles to work with, one might determine the proper remedial measures in a much more satisfactory manner. We are of the opinion that to accomplish this end it is only necessary to use the information that has been accumulated by past experiences in such a manner that one will think in terms of bronchial obstruction rather than in terms of any one condition or disease. *We would then become more bronchial-obstruction-minded.*

A considerable proportion of the cases of intrabronchial foreign bodies will present a definite history indicating the possible presence of a foreign body. There is a small group of foreign body cases, as well as a large group of cases in which the obstruction is caused by endobronchial growths and inflammatory processes, together with those in which the obstruction is caused by extrabronchial lesions, in which the historical facts are elicited with difficulty. The ultimate diagnosis in many cases is dependent upon the history of an unexplainable cough or blood-spitting or some other symptoms which may be even more indefinite. This has led to a careful investigation of the physical and x-ray findings and to an ultimate bronchoscopic investigation.

The important physical signs of bronchial obstruction which past experiences have proven to be of importance are herewith listed:

(1) Limited expansion.

(2) Diminished breath sounds distal to the obstruction.

(3) Altered breath sounds at the site of the obstruction.

(4) Altered vocal fremitus (usually decreased).

(5) Impaired percussion note.

One should bear in mind the fact that, should the obstruction be complete, there may be an interval, before absorption of the air distal to the obstruction has taken place, when the percussion note is tym-

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

Fig. 1. Reveals a dense shadow in the region of the right stem bronchus, with slight increase in density in the lower portion of the lung-field. Molar tooth was removed at bronchoscopy. The obstruction being incomplete, it had been possible for air to enter and leave this lung and for some excretions to be expelled.

panic, only to be replaced later by a dull and finally by a flat note, as absorption takes place and atelectasis develops. At the same time, evidence of displacement of the mediastinal contents and narrowing of the intercostal interspaces may be elicited. If secretions accumulate distal to the obstruction, the evidence of displacement will not be so marked and the condition may be spoken of as "drowned lung." The distribution of râles varies with the site, the completeness, and the duration of the obstruction.

The roentgenologic findings in the presence of a bronchial obstruction are, likewise, dependent upon the location, the character, the completeness, and the duration of the obstruction.

(1) If the obstruction is incomplete, the lung distal to the obstruction may present evidence of over-inflation by its increased transparency, and it may be noted that the mediastinal contents are displaced away from the affected side during expiration.

(2) If the obstruction is complete, there will be an increased density over the affected portion of the lung, and, if the air is not replaced by secretion, the mediastinal contents may be shifted toward the affected side. The intercostal interspaces on that side will be narrower and the hemidiaphragm fixed or elevated. If the air is replaced by secretion, the evidence of decreased lung volume will be less marked.

The importance of these general points and some additional ideas can best be emphasized by presenting a group of cases, all of which show some of the earmarks of bronchial obstruction, no two of which are at exactly the same stage in their development and no two are produced by exactly the same lesion, yet all can be grouped as bronchial obstruction. The diagnosis and treatment of the particular condition causing the obstruction were accomplished after all factors associated with it had been taken into consideration.

ACUTE INCOMPLETE OBSTRUCTIONS, ENDOBRONCHIAL

This type of obstruction is illustrated by the findings in Cases 1, 2, and 3.

Case 1. V. E., nine months of age, six hours before admission to the hospital had choked while eating peanut candy. At first the child was blue in the face but later appeared to be all right. Physical examination revealed a diminished excursion over the lower portion of the right half of the chest. The percussion note was hyper-resonant over this area. The breath sounds were distant over this area and the expiratory murmur was short. The fluoroscopic and x-ray studies revealed an increased translucency of the lower right half of the chest, with the mediastinal contents in a fairly normal position during inspiration, but displaced toward the left during expiration. The removal of one-half of a peanut from the right stem bronchus relieved the symptoms and led to

a correction of the other abnormal findings.

Case 2. A boy, 10 years of age, gave a history of having had a tooth extracted under gas anesthesia one week previously. He had not taken a smooth anesthetic and had coughed considerably afterward. Physical examination revealed limited motion over the lower portion of the right lung-field. The percussion note was not materially altered. The breath sounds near the root of the right lung were harsh, but distal to this area the sounds were distant. X-ray and fluoroscopic studies revealed little change, except the presence of a very dense shadow in the region of the right stem bronchus and a slight increase in the density of the lung-field in the lower portion of the field. Bronchoscopic investigation confirmed the diagnosis of an opaque object in the right stem bronchus, with incomplete obstruction, and resulted in the removal of a molar tooth, together with considerable fluid of a sanguino-purulent character (Fig. 1).

Case 3. A baby, eight months of age, had choked one hour previous to examination, while playing on the floor, only to recover after a few moments. This was followed by frequently recurring spells of cyanosis and respiratory difficulty. Physical examination at first revealed a child with a normal color which became cyanotic during the examination, only to clear up again. There was, at times, retraction of the infra- and suprasternal notches as well as of the intercostal spaces. At times, there was limitation of motion over one portion of the chest, only to be replaced by a similar limitation at some other point. The percussion note was always resonant. The breath sounds were distant at all times over some or all portions of the lung-field. There was an audible slap over the trachea at times. Fluoroscopic and x-ray studies revealed a movable object in the trachea and bronchi, its position changing from moment to moment. When the object was in the trachea there was increased translucency of both lung-fields, with depression of both hemidiaphragms and widening of the intercostal interspaces. When the object was in one stem bronchus these changes were noted on only the affected side and it was also noted that during expiration the mediastinal contents, particularly the heart, was shifted toward the uninvolved side. Bronchoscopic investigation confirmed the diagnosis and resulted in the removal of a pearl bead from the trachea (Fig. 2).

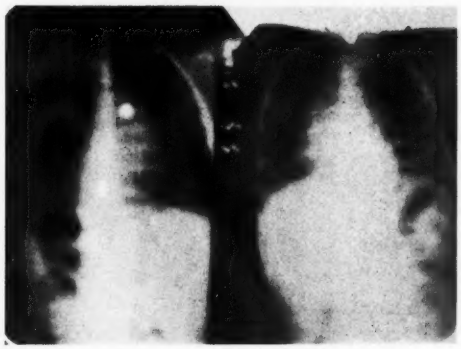

Fig. 2. In this case there is noted at one instant a very dense shadow in the upper trachea near the larynx and the next instant this same type of shadow is seen to occupy a place in the region of the right stem bronchus. This case illustrates the free movability of certain types of foreign bodies and also serves to emphasize the seriousness of what might seem at the time to be an insignificant accident.

In this group of cases it will be noted that there is a definite history, giving an indication of the probable presence of a foreign body. The physical signs are not the same in any two of them, yet some similar findings are present in all of these cases. The x-ray findings, likewise, present some similarities. Special attention should be called to the fact that in the case of the boy with the tooth in his bronchus (Case 2) sufficient time had elapsed to permit secretion to accumulate distal to the obstruction. We find, therefore, that there is an increase in density in this portion of the lung-field.

ACUTE COMPLETE BRONCHIAL OBSTRUCTION, ENDOBRONCHIAL

This type of lesion can be illustrated by Case 4, a white male, McM., 40 years of

age, who underwent an operation for appendicitis under spinal anesthesia. Six hours later there was an increase in the pulse rate, followed at the end of eight hours by an increase in the respiratory rate, and at the end of twelve hours by a rise of temperature. The patient was of a dusky slaty blue color. At this time there was dullness over the right side of the chest, with absent breath sounds and the cardiac impulse was displaced toward the right. The x-ray findings at the end of twenty-four hours showed a great increase in density over the right half of the chest except for a small area near the apex. The intercostal interspaces were narrow. The heart and mediastinum were displaced toward the right. The diaphragm on this side was elevated. A diagnosis of acute post-operative bronchial obstruction was made. Bronchoscopic investigations revealed the presence of a large amount of thick, gelatinous secretion filling the right lower and middle lobe bronchi, the removal of which gave instant relief of symptoms. Likewise, the immediate x-ray findings showed a definite return of the thoracic content toward a normal condition. Here the disappearance of the air from the lung resulted in a decreased lung volume, with a resultant decrease in the size of the thoracic cage on the involved side as shown by the elevated diaphragm, the narrow intercostal interspaces, and the displacement of the mediastinal contents toward the affected side.

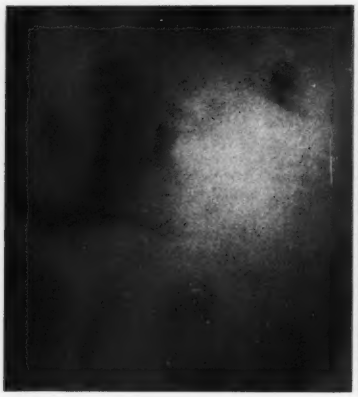

Fig. 3. Note the marked increase in density throughout the right lung-field, with the retraction of the heart into or toward the right side of the chest, with the narrowing of the intercostal interspaces on the right. (Case 4.)

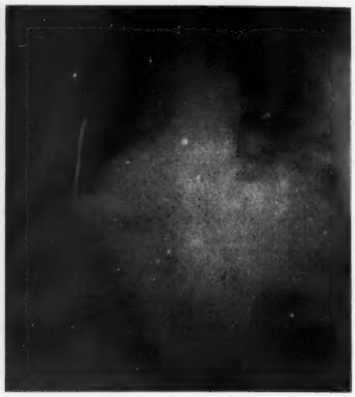

Fig. 4. Note the disappearance of the shadow of great density throughout the right lung-field, with the return of the heart shadow to its normal position. The interval between the two films (Figs. 3 and 4) is a short one.

CHRONIC COMPLETE BRONCHIAL OBSTRUCTION, ENDOBRONCHIAL

This condition can be illustrated by Case 5, a boy 11 years, 6 months of age, who had had a cough for seven and a half years. A diagnosis of whooping cough had been made at first, but as the years went by the cough became more and more productive and a very foul odor of the breath developed. In addition, there were frequent bouts of temperature—it rose at times to 103°. No evidence could be elicited of the boy having choked on a foreign body. Physical examination revealed the fact that the lower two-thirds of the right chest was practically immobile. The intercostal interspaces were narrow; tactile fremitus was absent; the percussion note was flat, and the breath sounds were absent. Numerous coarse and fine râles

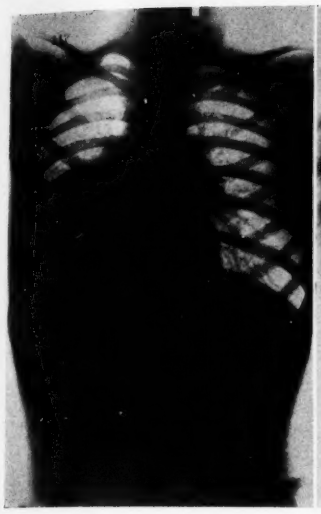

Fig. 5. There is an area of greatly increased density over the right lower lung-field, with some shifting of the heart toward the right side.

Fig. 6. Same case as shown in Figure 5. Note the presence of a foreign body of the density of metallic quality in the region of the right stem bronchus.

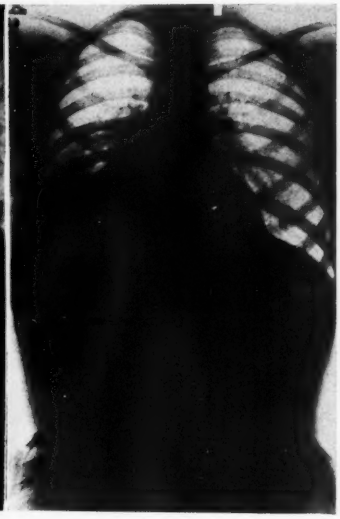

Fig. 7. Same case as shown in Figures 5 and 6. Note the disappearance of the shadow of metallic density. The area of great density extending to the diaphragm on the right has disappeared. This change has taken place over an interval of two weeks after relief from the bronchial obstruction by the bronchoscopic removal of a metallic screw from the right stem bronchus.

could be heard over the same area and some in the lower portion of the left lung-field, while x-ray studies revealed an area of greatly increased density over the lower portion of the right lung-field. The heart was displaced somewhat to the right and the intercostal interspaces on the right were narrow. In addition to the above findings, fluoroscopic studies revealed the presence of a very dense shadow in the region of the main stem bronchus on the right, further brought out in films and interpreted as being a rusty metal screw. Bronchoscopic investigation confirmed this impression and resulted in the removal of the screw, together with its deposit of rust. Within two weeks the cough and sputum had almost entirely disappeared and the physical and x-ray findings were approaching the normal. In this case we can see the same evidence of decreased lung volume as was seen in the case of an acute complete bronchial obstruction (Case 4). Here we find that numerous râles have replaced the quiet lung of the other case, which can be accounted for by the fact that there has accumulated much purulent secretion in this lung. In other words, we are dealing with a "drowned lung." (Figs. 5–7.)

COMPLETE OBSTRUCTION OF SMALL BRONCHI, ENDOBRONCHIAL

This type of lesion can be illustrated by a group of cases.

Case 6. A youth, 22 years of age, came complaining of a non-productive cough, temperature up to 101°, and a discomfort in the right lower half of the chest, posteriorly, symptoms which had developed during the previous seven days. Physical examination revealed a limitation of motion over the right lung-field in its lower and posterior portions. There was an impaired percussion note near the spine at the right base posteriorly, and the breath sounds were absent over a

Fig. 8. Note the area of increased density in the right lower lung-field, extending downward toward the diaphragm but occupying a medial position. There is no noticeable narrowing of the intercostal interspaces, but the diaphragm is slightly elevated.

Fig. 9. Same case as shown in Figure 8. Upon bronchoscopic removal of peridental membrane the shadow of increased density in the lower medial portion of the lung-field has disappeared and the diaphragmatic shadow is in a lower position.

corresponding area. A few râles could be heard. X-ray studies revealed an area of increased density which corresponded with the area over which the physical signs were altered. The fluoroscopic studies revealed also a limitation of the movement of the diaphragm on the right, with a slight shifting of the heart toward the right during inspiration. Further studies of the history brought out the fact that the patient had had a tooth extracted ten days previous to the time these studies were made. Bronchoscopic studies confirmed the diagnosis of a plugged secondary bronchus and resulted in the removal of a portion of peridental membrane from a right postero-medial bronchial division. Twenty-four hours later the temperature was normal and the other findings, including the x-ray findings, were approaching the normal (Figs. 8, 9).

Again we might point to the case of a girl (Case 7), seven years of age, who gave a history of having undergone a tonsillectomy ten days previously. On the third post-operative day her temperature had risen to 100° and had ultimately reached 105°, with marked malaise and general prostration. There was a non-productive cough. Physical examination revealed a limited excursion over the lower portion of the right lung-field, an impaired percussion note, a few râles near the midline, and the absence of breath sounds over the same area. Fluoroscopic and x-ray studies revealed an area of increased density over the same area, a shifting of the heart toward the right on inspiration, and partial fixation of the right hemidiaphragm. Bronchoscopic investigation confirmed the diagnosis of obstructed right secondary bronchus and resulted in relief from an inflammatory obstruction, distal to which a considerable amount of secretion had accumulated. Cultures revealed the presence of streptococci. Twelve hours later the temperature was 99°, and physical and x-ray findings were returning to normal.

There is the case of a girl (Case 8), seven years of age, who gave a history of having been ill with fever and cough over a period of several weeks. Her physician had treated her at first for an unresolved pneumonia. When seen, there was limitation of motion of the chest over the lower left lung-field. Fremitus was decreased over an area in the lower part of the left chest posteriorly. The percussion

note was impaired over this same region and the breath sounds were absent. X-ray studies revealed an area of increased density on the left near the hilum, with a gradual fading of the density as the distal portions of the field were approached. The movements of the lower chest wall and of the diaphragm on the left were restricted, and the heart shadow was seen to shift to the left slightly during inspiration. Bronchoscopic studies revealed the fact that the mucosa of one medial division of the left lower bronchus was very much swollen and completely closed the lumen. Much secretion was released when the obstruction was relieved. Cultures revealed the presence of streptococci. The symptoms and x-ray findings immediately cleared up (Fig. 10).

Finally, a boy 10 years of age (Case 9) gave a history of choking thirty minutes previously while he had a straight pin in his mouth. The pin disappeared. Physical examination revealed suggestive limitation of motion over the lower portion of the right lung-field posteriorly. No change in percussion note or tactile fremitus was noted. Breath sounds were disturbed very little, if at all. X-ray and fluoroscopic studies revealed the shadow of a pin in the lower right lung-field near the spine, with very little, if any, alteration of the density of this portion of the lung-field. The movements of the diaphragm were limited. Bronchoscopic investigation confirmed the diagnosis of endobronchial foreign body, tertiary bronchus, and resulted in the removal of a straight pin, with complete and immediate recovery of the patient (Fig. 11).

The changes noted in this group of cases may be less marked than those previously described, but the fact must be borne in mind that the area of lung involved is much less. It should especially be noted that in the case of the pin in a tertiary bronchus (Case 9), the very short interval which had elapsed between the time of the accident and the making of these studies was not sufficient for the air to be absorbed beyond the obstruction.

Bronchial obstruction due to lesions arising in the walls of the bronchus is illustrated by some cases of bronchogenic carcinoma.

Case 10. A white male, 31 years of age, gave a history of a non-productive cough and of blood spitting at intervals over a period of two years, with some lassitude and, in recent months, slight loss of weight. There was a feeling of respiratory restraint and a discomfort in the lower central portion of the chest. Physical examination revealed one area in the left lower chest, posteriorly near the midline, where the breath sounds had a very harsh bronchial quality. Distal to this area the breath sounds were faint. The x-ray studies gave no additional information. Bronchoscopic investigation revealed the presence of a small nodular mass projecting into the lumen of the stem bronchus from the orifice of a posterior medial division. It was noted that the orifice of this bronchus was fixed. Microscopic studies of this tissue confirmed a diagnosis of carcinoma. Deep x-ray therapy, together with the use of radium at the site of the lesion, resulted in relief of symptoms for four years.

Case 11. White female, 45 years of age, who complained of a non-productive cough, some shortness of breath, and slight loss of weight over a period of six months. Physical examination revealed some limitation of motion over the lower right half of the chest and at a point near the root of the right lung, at which the breath sounds were very high-pitched; distal to this point the breath sounds were somewhat suppressed. At times, coarse râles could be heard in the lower portion of the right chest. X-ray studies revealed the presence of an area of great density near the root of the right lung, with considerable increase in the density of the lung-field distal to this area; the heart was shifted to the right and the intercostal interspaces were narrowed; the diaphragm was elevated. Bronchoscopic examination revealed the presence of a mass in the right stem bronchus, which caused an incomplete obstruction, and at the same time it

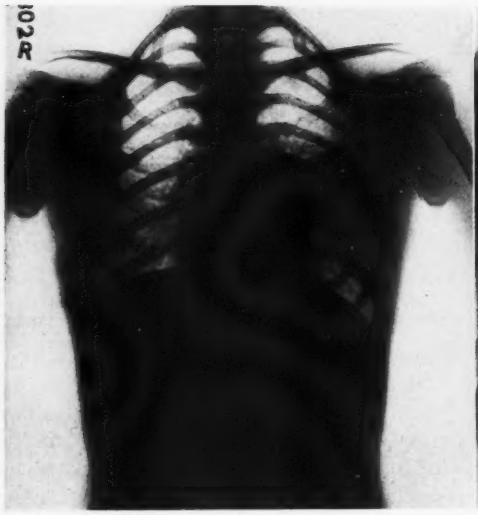

Fig. 10. Note the area of increased density extending from the root of the left lung downward along the border of the heart. This corresponds with the area of which physical signs showed a disturbance.

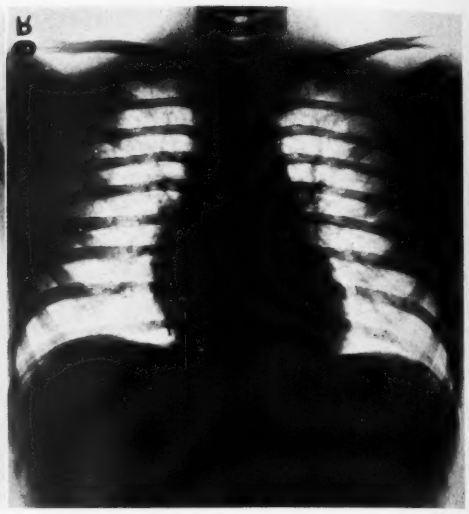

Fig. 11. Note a shadow of metallic density at the right base with one end resting almost on the diaphragm and falling within the shadow of the heart. There is practically no disturbance in the transillumination of this lung-field.

was noted that the lumen of the bronchus at this point was of a constant diameter, with no increase in diameter during inspiration or decrease during expiration. Microscopic sections confirmed the diagnosis of carcinoma. Within one month the bronchial obstruction became complete and the physical signs and x-ray findings became those of a complete obstruction, with an accumulation of secretion distal to the obstruction.

Case 12. Another case which further illustrates this type of obstruction is seen in a white male, 35 years of age, who gave a history of a non-productive cough, with some loss of weight, extending over a period of six months, together with some spitting of bright red blood during the previous two weeks. Physical examination at that time revealed some limitation of motion over the lower half of the left chest. The percussion note and tactile fremitus were near normal in quality, but near the left hilum there was a point at which the breath sounds were high-pitched and harsh. No râles were heard. X-ray studies at the time revealed the presence of an area of greatly increased density near the left hilum (Fig. 12).

Six months later the patient was seen again and at that time the chest over the lower left lung-field was immobile and narrower than on the right. Tactile fremitus was absent. The percussion note was flat over this area. The heart sounds could not be heard to the right of the sternum and there were no breath sounds over the lower left. X-ray studies revealed an area of greatly increased density over the left lower lung-field, with a shifting of the mediastinal contents, including the trachea, to the left. Bronchoscopic investigation revealed the presence of a mass completely filling the left stem bronchus, a large portion of which mass was removed. It was noted that the passage thus established was of a constant size during both inspiration and expiration. Microscopic studies confirmed the diagnosis of oat-cell carcinoma. Deep x-ray therapy, together with the endobronchial use of radium, have resulted during the past three months in the disappearance of the local evidence of the mass, together

Fig. 12. Note the shadow of increased density in the region of the left hilum. (Case 12.)

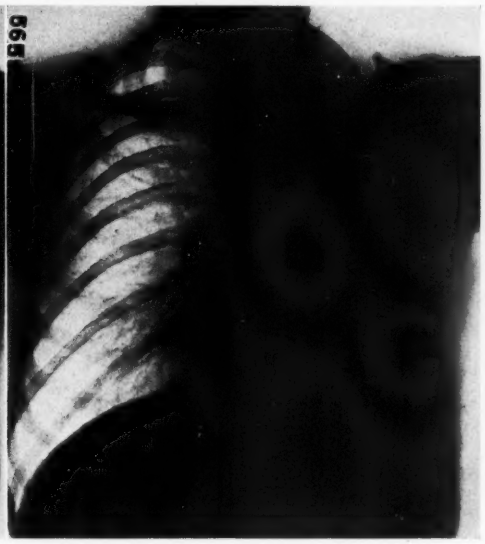

Fig. 13. Same case as shown in Figure 12, film made six months later. Note the greatly increased density over the entire left lung-field, with the disappearance of the heart shadow and the displacement of the trachea toward the left, with the narrowing of the interspaces on the left.

with increasing mobility of the bronchial wall at the site of the lesion. There remain some harsh qualities to the breath sounds over the site of the lesion. The x-ray studies reveal the fact that the area of greatly increased density has almost entirely disappeared and the trachea has shifted back to its proper position.

We should note especially the fact that the symptoms in this group of cases are very much less distressing than one might expect them to be, when produced by such serious lesions. Of special importance is the fact that in this group of cases we have not noted evidence of obstructive emphysema, whereas in the cases of intrabronchial foreign bodies such a finding was common. We would explain this phenomenon by pointing out the fact that in this group of cases we find the lumen of the bronchus at the site of the obstruction to be of a constant size and that air leaves the lung through this passage as readily as it enters. So although the lumen of the bronchus is narrow, as we look at it, still, because of the fact that the normal physiologic narrowing of expiration is eliminated, we have no more air entering this portion of the lung than can leave it. We should also note that with the clearing up of the local

Fig. 14. Same case as shown in Figures 12 and 13. Photomicrograph of a section from the bronchial wall showing the great infiltration of this wall with cells of the carcinoma as well as the proliferation of the connective tissue. This explains the fixation of the wall of the bronchus so that all mobility is lost.

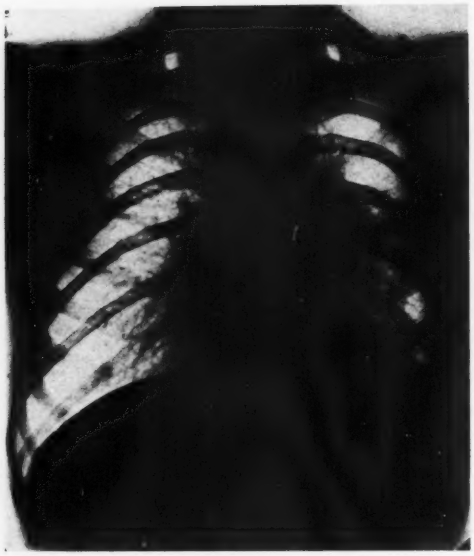

Fig. 15. Same case as shown in Figures 12–14. After x-ray and radium treatment the greater portion of the findings shown in Figures 12 and 13 have disappeared. There has been a shifting of the heart shadow back toward the normal position.

Fig. 16. Note an area of increased density extending from the right root outward and downward. (Case 13.)

infiltrative lesion the normal physiologic peristaltic action of the bronchial muscles returns. We might add that we are confident this is true in all cases in which the muscle fibers have not been too greatly destroyed.

EXTRABRONCHIAL LESIONS, WITH PARTIAL OBSTRUCTION

This type of lesion is illustrated by the report (Case 13) of a white male, 63 years of age, who had gradually lost weight during an interval of about three months. There had been increased lassitude and weakness, together with a cough that at first was non-productive, but toward the last was productive of considerable quantities of purulent secretion. There was considerable cyanosis. The temperature was variable. Serologic studies revealed a positive Wassermann. Physical examination revealed some immobility of the chest over the lower right lung-field; tactile fremitus was present; the percussion note was dull, and the breath sounds were bronchial in character, but they were somewhat suppressed. Numerous coarse râles could be heard throughout the lower right lung-field. X-ray studies revealed the presence of an area of increased density extending from the right hilar region to the periphery and downward, with the outer margin of the field having considerable translucency, while the heart seemed to be shifted to the right. Bronchoscopic investigation revealed the fact that the bronchial mucosa was intact although moderately inflamed, and was bathed in considerable quantities of purulent secretion, while in addition, there was a dinging in of the wall of the lower stem bronchus from its lateral and anterior aspect. A diagnosis of bronchial obstruction due to pressure by a mass on the outer wall was made, an opinion which postmortem findings confirmed. Microscopic sections from the mass established the diagnosis of a peribronchial gumma.

Another example of obstruction due to a lesion outside the bronchus is seen in the findings in Case 14, a white male, 43 years of age, who had been losing weight for a year and had a productive cough,

with blood-spitting. The sputum was negative for tubercle bacilli and the serologic studies were negative. Physical examination revealed a fixation of the chest over the right lung-field; the tactile fremitus was much decreased and the percussion note was dull, while many râles could be heard. X-ray studies revealed a great increase in density over the corresponding area, with some displacement of the mediastinal contents toward the affected side. Bronchoscopic studies revealed the fact that the bronchial mucosa was intact and was bathed in much purulent secretion. The lumen was obliterated by a dinging in of the bronchial wall from in front and to the lateral side. A diagnosis of bronchial obstruction due to pressure from without was made, an opinion which postmortem findings confirmed, also revealing the presence of large masses of tuberculous lymph glands as the offending factor.

In this group of cases, changes in the lung-fields are likely to develop somewhat later and will be due chiefly to accumulation of secretion and to secondary infection. Because of the flexibility of the bronchial wall and its ability to adapt itself to its altered surroundings, complete obstruction is usually much delayed.

SUMMARY

We have presented a group of cases illustrative of the different types of bronchial obstructions, together with the important historical, physical, roentgenologic, and bronchoscopic findings. In each case it has been possible to establish a working diagnosis of bronchial obstruction without regard to the causative agent. The selection of remedial measures has been dependent upon the establishment of the etiologic factors.

CONCLUSIONS

1. Bronchial obstruction can be dealt with as a definite entity.
2. The causative influences are varied and may lie within the bronchial lumen or within the wall of the bronchus, or may be entirely extrabronchial.
3. The treatment must be varied in accordance with the causes concerned.
4. Early diagnosis and treatment are highly essential and good results are dependent upon one's ability to relieve or remove the etiologic factors.

Fig. 17. Same case as shown in Figure 16. Photomicrograph of a section of an extrabronchial gumma removed at postmortem.

THE PROBLEMS OF PROTECTION AND THEIR SOLUTION IN SHORT WAVE ROENTGEN THERAPY[1]

By T. LEUCUTIA, M.D., *Associate Roentgenologist, and* K. E. CORRIGAN, PH.D., *Physicist, Harper Hospital, Detroit, Michigan*

THE International Recommendations for roentgen-ray and radium protection, which were elaborated at the Second Congress of Radiology, in Stockholm, in 1928, and revised at the Third Congress, in Paris, in 1931, are now observed by most roentgen-ray and radium workers throughout the world. These Recommendations are also steadily assuming increasing importance with various lay organizations, such as hospital boards, insurance companies, health agencies, etc., whenever the question of application of roentgen rays or radium is being considered. More recently, the health committee of the League of Nations, by collecting from the literature a bibliography of between five and six hundred articles and assembling all the protective measures adopted by the various countries, issued a most comprehensive pamphlet dealing with the subject.

In America, an Advisory Committee on Roentgen-ray and Radium Protection was formed shortly after the International Congress, at Stockholm, in 1928. This Committee is composed of two members of each radiological society, two members appointed by the manufacturers of x-ray equipment, and one by the American Medical Association, the Chairman being Lauriston S. Taylor, of the International Safety Committee and National Bureau of Standards. After much laborious work, the Committee prepared "a unified set of safety recommendations" for the United States, and published them, in 1931, in the form of a book called "Handbook No. 15, of the Bureau of Standards."

In analyzing these Recommendations, from the standpoint of protection from the short wave roentgen rays emitted by high voltage apparatus above 200 K.V. peak, which have begun to occupy such an important part in the realm of radiation therapy during the last two years, we find that they are as yet inadequate. This is shown in Table I.

TABLE I

International Recommendations		American Recommendations	
X-rays generated by peak voltages	Min. equivalent thickness of lead	X-rays generated by peak voltages	Min. equivalent thickness of lead
Not exceeding K.V.	Mm.	Not exceeding K.V.	Mm.
75	1.0	75	1.0
100	1.5	100	1.5
125	2.0	125	2.0
150	2.5	150	2.5
175	3.0	175	3.0
200	4.0	200	4.0
250	6.0	225	5.0
300	9.0	300	9.0
350	12.0	400	15.0
400	15.0	500	22.0
		600	34.0
		900	

Provision is made for the protection against direct radiation, the equivalent lead thickness values being extended in the International Recommendations up to 400 K.V. peak, and in the American up to 600 K.V. peak, but the protection against the scattered radiation from the walls of the treatment room or patient, and especially against the stray radiation produced by various sections of the roentgen-ray tube, this latter reaching formidable proportions with increasing voltages, is completely omitted. All that the International Recommendations provide in this respect is: "In the case of x-ray treatment, the operator is best stationed completely outside of the x-ray room behind a protective wall of a minimum lead equivalent of 2 millimeters. This figure should be correspondingly increased if the protective value of the x-ray tube enclosure falls short of the values given in Table I. In such

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

an event, the remaining walls, floor, and ceiling may also be required to provide supplementary protection for adjacent occupants to an extent depending upon the circumstances." The American Recommendations, which are considerably more elaborate, contain, in detail, provisions for the protection from scattered radiation of therapeutic apparatus, up to 250 K.V., dividing them into two groups: Class B, up to 140 K.V. peak, and Class C, from 140 to 250 K.V. peak.[2] However, as yet no mention has been made of the protective requirements for installations above 250 K.V. peak. From a study of the rules of the Class C installation, and by applying the higher lead thickness values as expressed in Table I, one may, by inference, be able to deduct certain safety rules for apparatus above 250 K.V. peak, but only experience will furnish the necessary practical data proving these rules.

Having more than a year ago installed in Harper Hospital a roentgen-ray apparatus capable of operating at 700 K.V. constant, we had the opportunity to experimentally study the most suitable protective measures against the radiation emitted by such a powerful installation. On the basis of the data accumulated so far, we would like to present at this time some practical conclusions concerning the radiation protection, as well as the safeguards against electrical accidents, and some protective measures of a more generalized character, such as ventilation, air ionization, *et cetera*. For the sake of convenience, and to conform as much as possible to the classification and terminology used by the Advisory Committee on X-ray and Radium Protection (as expressed in Handbook No. 15 of the Bureau of Standards), we will divide our subject, which deals with very short wave roentgen-ray installations at voltages from 250 K.V. to 1,100 K.V., as follows:

I. Protection from roentgen rays:
   (*a*) Protection from direct radiation;
   (*b*) Protection from scattered radiation originating from treatment cell;
   (*c*) Protection from stray radiation originating from machine plant room.
II. Electrical protection
III. General protection.

[2] Class A, representing the installations used for diagnostic purposes with voltage up to 130 K.V. peak.

I. PROTECTION FROM ROENTGEN RAYS

(*a*) *Protection from Direct Radiation.*—For the protection against the harmful effect of direct radiation generated with voltages up to 250 K.V. peak, both the International and American Recommendations specify that the roentgen tube must either be completely surrounded or enclosed in a protective material of lead equivalent value which corresponds to the figures of Table I. The American Recommendations, in addition to this, provide that a sheet of lead, of thickness in accordance with Table I, shall be placed in the path of the direct or useful beam on the floor, wall, or ceiling opposite the diaphragm, and made to extend one foot in all directions beyond the border of the roentgen-ray beam, which is determined by the largest possible aperture in the tube enclosure. In case the radiation is taken off in several directions, and there is any doubt as to the limits of the beam, the whole room should be lined with lead in accordance with Table I.

By trying to apply the above specifications to the short wave radiation, generated by voltages between 250 K.V. and 1,100 K.V. peak, it becomes evident that two difficulties will prevent their rigid enforcement. First of all, it is practically impossible to completely surround or enclose the roentgen-ray tube with protective lead, which would be adequate to shield off direct radiation in all directions, and secondly, the lining of an ordinary treatment room, in part or in its entirety, with such large quantities of sheet lead as to afford the required protection against all radiation (direct and, as we shall see later, scattered), creates new elements of construction.

The first difficulty largely resolves itself into a problem of tube design. It has already become the tendency in recent years to build the protective material of a roentgen tube directly into the wall of the tube so as to reduce the size of the outfit, and there are now numerous tubes, especially in the roentgen diagnostic field, which make use of this principle. In the therapeutic field, where the tube must be of considerably greater dimensions and, therefore, large quantities of protective material would be needed to produce a complete shielding off of the radiation, the incorporation of the protective material into the tube itself becomes, with increasing voltages, a matter of necessity. Up to 250 K.V. peak, it is yet possible to enclose the entire roentgen tube in a large lead box or drum as specified in the protective recommendations. However, as soon as the capacity of the tube is increased beyond that voltage, its dimensions start to assume such formidable proportions that a complete surrounding with equivalent lead, which *per se* has to be increased because of the greater penetration of the rays, becomes a practical impossibility, or, to say the least, a problem of tremendous practical disadvantage. To surround, for example, a 14-foot, 3-sectional Coolidge tube, or a Lauritsen tube from 10 to 30 feet long, with the equivalent lead thickness which, at 1,100 K.V. peak, would be in the neighborhood of 3 inches of sheet lead, would mean the use of thousands of tons of lead, especially if one takes into consideration the high electric clearance necessary at such high voltages.

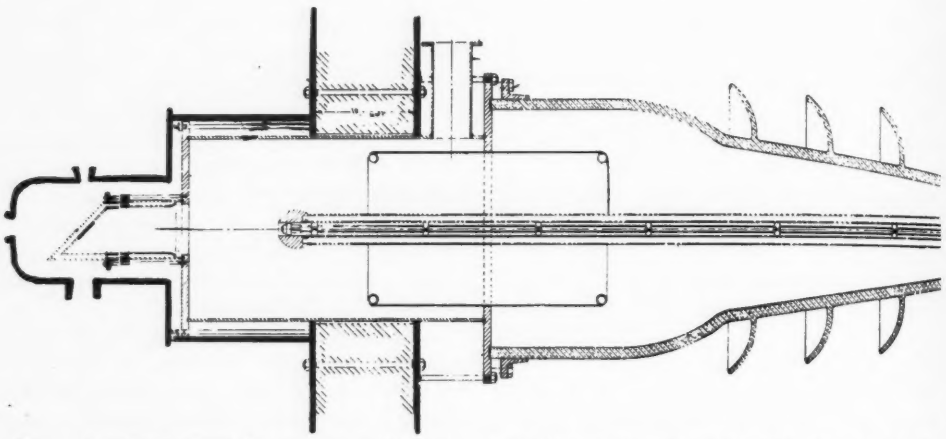

Fig. 1. Lauritsen's porcelain x-ray tube of 700 K.V. and its lead protection (heavy line indicating sheet lead).

In the following, we will present our tube arrangement, which permits the solution of the radiation protection problem in a rather simple manner. *A priori*, we would like to state, however, that it is not the purpose of this article to enter into a detailed description of the tube construction proper, for this can be found elsewhere. It is our desire to briefly discuss only that phase of the construction which refers to the building in of the radiation protection material. As shown in Figure 1, it is a Lauritsen tube making use of porcelain in the form of a conical transformer bushing instead of the usual glass for wall material. The porcelain is joined into a steel tank, which projects through the lead wall into the treatment cell and terminates in the form of a narrow cylinder at the roentgen-ray emission end of the tube. It is now possible completely to surround the steel tank and the roentgen-ray emission end of the tube, from the lead wall on, with sheet

lead of the desired thickness (1-inch up to 500 K.V., to 2-inch up to 900 K.V., etc.). Both the steel tank and the narrower steel cylinder being grounded, the sheet lead can be brought very close. On the steel cylinder, the sheet lead lies directly on the cylinder's outer surface, whereas on the narrower cylinder, a small interspace is allowed, the protective lead being molded in the form of a cap. Inasmuch as the target, which in our tube is at 45°, forms the end of the narrower cylinder, one or several suitable apertures can be provided in the lead cap, allowing the useful radiation to emerge. It may be mentioned here that the filament in our tube is on the spherical end of a steel holder which, after traversing from the high potential end of the generating apparatus through the entire length of the tube, ends freely within the steel tank, barely 20 inches away from the target. In this manner, the roentgen rays are generated entirely within the protected end of the tube, which, as mentioned above, projects into the leaded treatment cell.

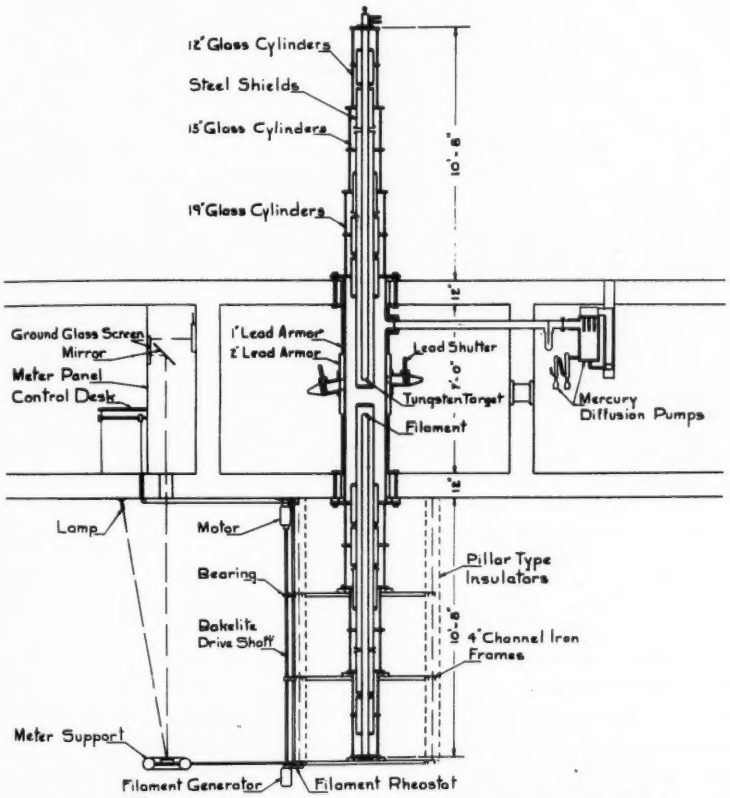

Fig. 2. Lauritsen's centrally protected x-ray tube of 1,100 K.V. (Kellogg Radiation Laboratory of the California Institute of Technology.)

In the type of tube in which the roentgen-ray emission is in the middle of the tube, a protective sheet lead enclosure is affixed to this portion. Figure 2, which shows the installation at the Kellogg Radiation Laboratory of the California Institute of Technology, illustrates a vertical tube arrangement in which the central portion of the tube is surrounded by a 2-inch sheet lead cylinder (at 900 K.V.),

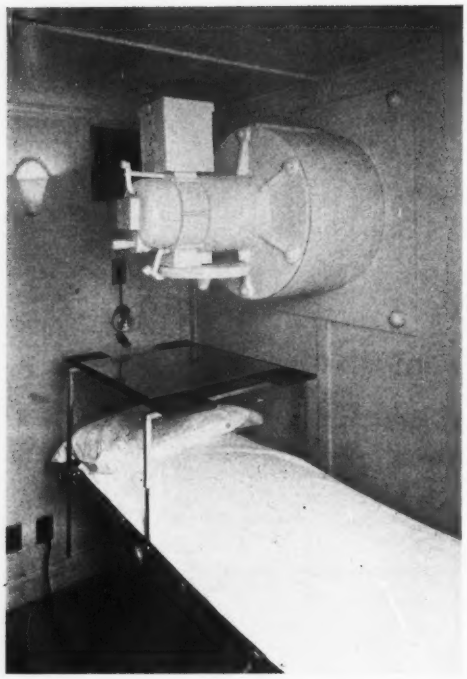

Fig. 3. Interior of leaded treatment cell, when roentgen-ray emission is from the end of the tube.

four apertures being provided for the simultaneous treatment of four patients by the radiation emitted from one single target. The apertures are placed at a 45° angle so as to direct the roentgen-ray beam toward the corners of the treatment cell, thus affording additional protection. The entire tube is 30 feet long, the treatment cell being suspended around the leaded central portion, which is grounded. Of course, there are other possible tube arrangements. A tube, with ray emission at one of its lead shielded ends, may project vertically through a ceiling into a treatment cell which is underground, having concrete as protective material of its walls. Likewise, a centrally protected roentgen-ray tube may lay horizontally and the rays may be taken off through four apertures into four individual treatment cells, one being above, one below, and two laterally, from the tube, *et cetera*.

The second difficulty leads to the necessity of constructing a special treatment cell of the smallest dimensions possible, so that all of its walls can be completely covered with sheet lead or its equivalent. It is advisable that this cell be immediately adjacent to the machine plant, so that the roentgen-ray tube can be built into one of its walls. To prevent the escape of any radiation, all joints, holes, or openings, which are made in the lead wall, must be carefully covered by an equal thickness of lead. In our installation, the walls of the treatment cell (Fig. 3), which is 6 × 9 × 12 feet inside, are lined with 1-inch lead plates, a double thickness being provided in the wall opposite the end of the x-ray tube and toward the control room. These plates are welded, and a 1-inch overlap is provided for all joints; the floor and ceiling are also protected with two inches of lead. All of the walls are without any kind of opening, with the exception of very small holes for instrument cables, carefully plugged and overlapped with lead. An air duct enters the room at the floor in one corner, and a similar duct leaves the room near the ceiling on the opposite side, to connect to a large exhaust fan. The internal orifices of these ducts are constructed of lead baffle plates (one inch in thickness) which overlap. Through these ducts, the entire volume of air in the room can be changed in four minutes and provision is made for controlling the temperature of the air. All openings are remote from the roentgen tube, and at such angles as to be impenetrable to direct radiation in any case. The room is provided with a polished hardwood floor, and the walls are finished with beaverboard and plywood. In this way, sufficient organic material is provided so that the secondary radiation is considerably reduced, the only source of a measurable amount of it being the spot on the floor under the head of the tube where the primary beam strikes the floor. The patient is protected from this beam by the base and the body of the table, which are both of wood.

Access is gained to the treatment cell through a narrow passage, provided at

each end with leaded doors. The doors into the transformer room also carry lead plates; in fact, all of them overlap at the joints, jambs, and sills.

must be so arranged that the useful beam does not point toward the operator. In our installation, this wall is partly of concrete, and covered to a height of 8 feet

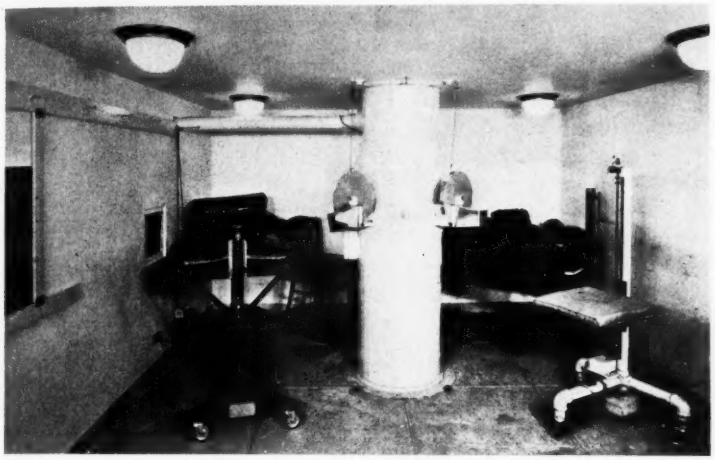

Fig. 4. Interior of leaded treatment cell, when roentgen-ray emission is from the central portion of the tube.

Figure 4 shows the treatment cell of the Kellogg Radiation Laboratory of the California Institute of Technology, suspended in a concentric manner around the lead-shielded central portion of the roentgen-ray tube. The walls of this cell are constructed of concrete, 1 foot thick, which is equivalent to a 1-inch sheet of lead. The treatment is carried out through four apertures simultaneously: two of the patients receive irradiation while lying on couches, and the other two while sitting in chairs.

(*b*) *Protection from Scattered Radiation.*—The construction of treatment cells, with adequate lead walls and built-in ray emission ends of the roentgen tube, also takes care of all scattered radiation emanating from the walls of the treatment cell or patient. Of course, all control apparatus must be located in a separate room, where the operator sits. The walls near the treatment cell, and, as we shall see later, the machine room, must receive additional reinforcements either by concrete or sheet lead, and the roentgen tube with 1-inch lead plates welded and overlapped as in the treatment cell. To completely eliminate any leakage of scattered radiation, we have installed a periscope, instead of the usual lead glass window, for observation of the patient. This instrument has an objective lens which fits into a hole, only 0.5 inch in diameter, in the wall of the treatment cell and is provided with two 90° bends before penetrating the wall of the control room, allowing for adequate baffling. The patient and operator communicate with one another by means of microphones fitted with loud speakers, the wires of which are led through the baffled air ducts.

(*c*) *Protection from Stray Radiation.*—Under the term "stray radiation" we wish to designate all radiation which is produced within the generating room, and which, in the very high voltage apparatus, may reach formidable proportions. The sources of this radiation are manifold: part of it originates from the back-scattering of the roentgen rays from the target; another

part is generated by the electrons hitting various parts of the roentgen-ray tube, especially if there is a great distance between the cathode end (filament) and target, as in the multisectional tubes, and, finally, a third part is produced by the thermionic rectifiers, in the installations in which such tubes are used for rectification. It is evident that many of these rays must be of quite short wave length and that, in consequence, especially when voltages above 600 K.V. are used, they must constitute a source of great danger not only to the personnel of the operating staff, but also to the entire neighborhood.

To protect against these rays, it appears safest, whenever possible, to house the entire equipment in a separate building, having free walls toward an open space in all directions except the side toward the control room, which would then be connected by a long corridor to the rest of the hospital. It is possible that future improvements in the engineering design of the tube may later contribute toward the elimination of the radiation originating from it. The building-in of an adequate protective ring, in the proximal end of the narrow cylinder, may, for example, cut out most of the back-scattering from the target. On the other hand, by a rebuilding of the electrodes, making use of the electron screen principle, as already done in some of the foreign tubes, one may be able to prevent the diffusion of the electrons and thus the formation of stray radiation from the walls and other portions of the tube. The rays produced by the thermoionic tubes become negligible in cases in which smaller individual units are used in cascading the high voltage.

II. ELECTRICAL PROTECTION

The safeguard rules against electrical accidents are, in the main, those provided in the American Recommendations for the installation of all x-ray apparatus. We may add only that it appears wise to supply all doors (those of the treatment cell as well as of the generating room) with circuit breakers, so that the machine is instantly shut off as soon as any of the doors are opened. In cases in which condensers are used in the transformer units, an automatic dissipator must be supplied, which grounds the high tension end of the tube the moment the machine is stopped. The danger of puncturing the water pipe leading to the target can be entirely disregarded here, for the cooling device is grounded, tap water being used directly. Likewise, the pumping pipe connecting the tube with the pumping system cannot possibly act as a conductor of the high voltage to the control board, for it is connected to the grounded points of the tube.

From the point of view of the patient, the danger of a high tension accident is *nil*. Because the roentgen emission end of the tube, together with the lead cap and the welded lead plates of the treatment cell are connected to deep ground rods by means of several heavy cables, the patient is absolutely protected from the high tension current as well as from all forms of static charges. The grounding of the tube has an additional advantage in that it permits the irradiation from a very short distance without the slightest danger to the patient.

III. GENERAL PROTECTION

We would now like to discuss three protective measures which result from the more general effect of the highly penetrating rays produced by the high voltage apparatus. These are as follows: (*a*) the advisability of a remote control room; (*b*) the necessity of a thorough ventilation for the operator, and (*c*) the necessity of the regulation of the working hours for the personnel.

(*a*) *Remote Control Room.*—It is now an established fact that lead is not absolutely impervious to rays of a very short wave length and, the nearer we approach the gamma rays of radium, the more transparent the proportional lead thicknesses become. Thus we find that at 500 K.V.,

1 inch of lead, and at 900 K.V., 2 inches of lead, appear quite transparent, these figures increasing considerably with still higher voltages. From a practical standpoint, this means that, no matter how large the quantities of lead we use for the protection against the total ray output emanating from the tube, a certain amount of radiation will always reach the operator. This amount becomes larger, the higher the voltage used, and consequently the shorter the wave length of the rays produced. Under these circumstances, it seems that, in a manner similar to radium protection, distance is the only factor which can afford some sort of security and, therefore, the removal of the control room as far as possible from the operating roentgen-ray tube appears necessary. The provision of a periscope for visional control and of microphones and loud speakers for direct verbal communication with the patient, greatly facilitates such an arrangement.

(*b*) *Thorough Ventilation of Control Room.*—The installation of a remote control room serves another good purpose which is directly in connection with the ventilation of the air around the operator. Recent investigators have proven, beyond doubt, that the ionization of the air in roentgen rooms produces no little deleterious effect on the operating personnel. As is known, this air ionization is caused partly by the roentgen rays and partly by the electrical diffusion of the high voltage conductors. By removing the control room as far as possible from both sources, the air ionization around the operator will be reduced considerably. Adding to this an enforced exhaust ventilation, capable of completely changing the air of the control room not less than ten times an hour, as provided for all roentgen rooms in both the International and the American Recommendations, the danger from the air ionization will be reduced to a minimum.

(*c*) *Regulation of Working Hours for Personnel.*—Despite all the above protective measures, it probably will prove necessary, with time, strictly to regulate the working hours and the "off-time" of the operating personnel. In this respect, the rules will have to be even more strict than those for the protection from radium rays. It was calculated by Failla, for example, that at 700 K.V. and 5 ma., the radiation emission through 5 mm. Cu is equivalent to the gamma-ray emission of from 400 to 600 grams of radium, depending on the criterion of equivalence chosen. By further raising the voltage, this equivalence assumes quite tremendous proportions, so that the distant effect becomes of the greatest importance. That this effect will injure the personnel, with the tube running several hours a day, need not be stressed any further.

CONCLUSIONS

The advent of very high voltage installations has created new problems of protection. It is proposed that the solutions of these problems be incorporated in the already existing American and International Recommendations. Especially is it advocated that a new group be created in the American Recommendations, the Class D installation for apparatus running at voltages from 250 K.V. upward. The protective requirements for the very short wave roentgen rays, generated by such installations, shall then include the following:

I. Protection from roentgen rays.
   - (*a*) Protection from direct radiation;
   - (*b*) Protection from scattered radiation originating from the treatment cell;
   - (*c*) Protection from stray radiation originating from the machine plant room.

II. Electrical protection.

III. General protection.
   - (*a*) Remote control room;
   - (*b*) Thorough ventilation of control room;
   - (*c*) Regulation of working hours for personnel.

It becomes evident, from all that has been said in the main part of this article, that because of the intricate manner in which the protection must be embodied in the construction of the apparatus and the general lay-out of the entire plant, the installation of very high voltage roentgen-ray units will probably, at least under present technical conditions, remain limited to the larger institutions.

CASE REPORTS AND NEW DEVICES

DYSCHONDROPLASIA

WITH REPORT OF THREE CASES

By M. L. WEINSTEIN, M.D., *and*
H. COTELL, M.D., *Chicago*

Dyschondroplasia is a definite form of cartilaginous dystrophy, usually congenital in origin, and either unilateral or symmetrical in distribution. It is found more often in males than in females. The cases reported show a marked familial and hereditary tendency.

Ollier (1899) was first to describe this condition of bone dystrophy, and reported a case of dyschondroplasia in which there was a unilateral dwarfing of the limbs due to retardation in growth, and an irregular ossification at the diaphyso-epiphyseal junction of the long bones, especially those of the feet and hands. He emphasized the unilateral distribution of this deformity.

Kummer (1900) reported on the same condition and named it "Ollier's disease." He was the first to make a detailed roentgenologic study of this disease and to describe its exact nature. He characterized it as an irregularity and a retardation in the process of ossification of the cartilage, principally in the diaphyseal ends of the long bones. He presumed this cartilaginous tissue to persist abnormally in the form of nodules or masses in the periosteum or deeply in the medulla. These ossify spontaneously and very slowly, to form chondromas. He, therefore, defined this condition as a chondromatosis with a systemic involvement of the skeleton, characterized by the presence of multiple chondromas localized without any definite rule in any of the skeletal segments.

Fig. 1. Case 1. A hard, rough, and bony tumor, the size of an orange, protruding from the posteromedial surface of the left leg just below the knee.

According to Ehrenfried (1915), Virchow described a similar condition and called it "multiple cartilaginous exostosis." Ehrenfried reviewed over 600 cases in the foreign literature and over 75 cases in the American literature, covering a period between 1900 and 1917.

Hale (1930) reviewed 53 cases found in the literature between 1917 and 1930, and described the symmetrical distribution of the bony or cartilaginous tumors, situated mostly at the diaphyseal side of the epiphysis, and, occasionally, on the shaft of the long bones, where there is normally the greatest amount of growth. He did not differentiate between the terminology of "dyschondroplasia" and "multiple cartilaginous exostosis" and used them synonymously.

Keith (1919) described the anatomy and physiology of Ollier's disease and considered it as an extreme example of diaphyseal aclasis. He included multiple cartilaginous exostosis in the same category of bone dystrophies as dyschondroplasia, and concluded that both showed the identical nature of growth disturbance.

Stocks (1925) reviewed 495 cases of diaphyseal aclasis and 142 cases of multiple enchondromas. He classified and separated the cases of isolated exostosis from those associated with enchondromas, and concluded that Ollier's disease was not a separate entity.

The microscopic sections of the deformed bone showed no structure similar to chondromas, a finding which was confirmed by Johannenson (1923), who found no sign of inflammation or tumor in the sections made from his case. It showed a hyaline network

Fig. 2. Case 1. Smaller protuberances on either side of the lower ends of both femora.

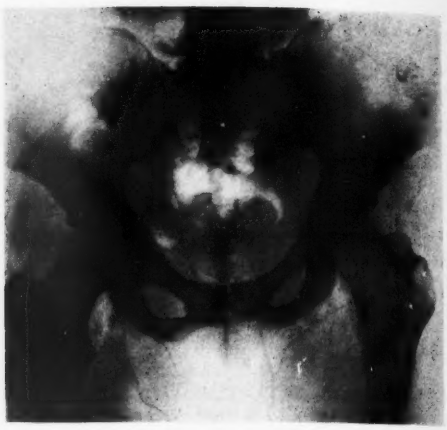

Fig. 3. Case 1. Small hard nodules were palpable over the anterior surfaces of the crest of the right ilium and the right hip joint.

Fig. 4. Case 1. Fusion of the lower ends of the tibiæ and fibulæ.

rich in cells—extraordinarily numerous but absolutely typical and normal in appearance.

Dyschondroplasia is essentially a growth disturbance in which the activity of the cartilaginous and the periosteal elements are involved. The membranous bones such as those of the face, vault, and skull are never affected. The changes occur where the processes of membranous and cartilaginous bone formation come into juxtaposition, which usually occurs at the diaphyseal end of the long bones and at the growing margin of the innominate bone and of the scapula.

John Hunter described the process by which bone grows in length. In the diaphysis, there is first of all a deposit of a cylinder of new bone, which undergoes remodeling before it is incorporated into the shaft. This process is accomplished by the construction of a bony ferrule around the irregular bony cylinder by the periosteum. An arrest of this remodeling process occurs in dyschondroplasia. The presence of a large mass of cartilaginous bone

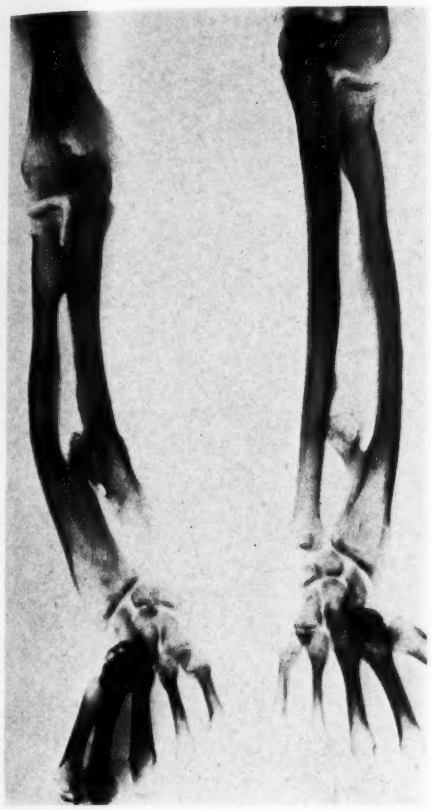

Fig. 5. Case 1. There was a marked bowing of both radii and ulnæ, especially the right, with exostoses at the lower ends of the shafts of the radii. The lower end of the left ulna was incompletely developed and partly fused with that of the corresponding portion of the radius.

Fig. 6. Case 2. A bony exostosis on the posterolateral aspect of the upper third of the right thigh. Roentgenologic examination showed this tumor and also smaller bony exostoses projecting from the diaphyseal region of both femora, with rarefaction and widening of the diaphyses.

at the growing ends, which is no longer restrained by the growing ferrule, provides an opportunity for the outgrowth of multiple cartilaginous tumors. Many of these may remain small and latent until puberty or they may be discovered accidentally during the course of an examination.

The symptoms in the case of dyschondroplasia vary with the extent of the deformity and the degree of disordered growth activity. There may be a stunting in general stature but, more often, there is none, as in our three cases in the same family. The limbs may be definitely stunted and there may be limitation of motion in the joints. The presence of a hard painless swelling attached to the ends of the long bones, to the scapulæ or pelvis may be noted on palpation. An arrest of growth at the lower end of the ulna is commonly seen, so that the radius becomes curved and its upper end may be dislocated. The lower ends of the tibia and the fibula usually undergo fusion, a finding which is well demonstrated in one of our cases. Secondary deformities are usually found in older patients and are most marked in the forearm and ankle joints.

A roentgenologic examination usually shows the exostoses and the bowing and fusion of the ends of the bones, mentioned above. In the typical Ollier's disease with a unilateral deformity, one side of the skeletal bones, such as the ilium, femur, and tibia, may be smaller and shorter than those of the opposite side. A characteristic picture is the irregularly expanded diaphyseal mass, with an absence of the cortex. The diaphysis usually shows irregularly shaped areas of rarefaction through which run dense lines, oblique to the long axis of the shaft. Between these lines are clear spaces interposed with small dense nodular shadows having conglomerate appearance (11).

This condition is usually compatible with good health and active life. Occasionally one or more of the multiple tumors increase in size during adolescence and this may cause discomfort or deformity and interfere with the patient's daily routine, in which case surgical removal of the tumors may become necessary.

There seems to be a general agreement as to the benign character of the lesion. Hume (1929) mentioned the possibility of the appearance of osteogenetic sarcoma in the exostosis, but stated that its occurrence is rare.

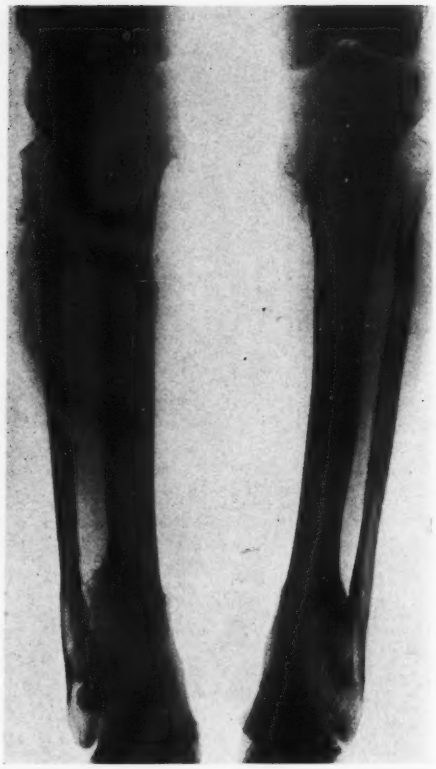

Fig. 7. Case 2. Small exostoses were found about the upper ends of both tibiæ and fibulæ, and there was fusion of the lower ends of these long bones.

Several cases of malignancy have recently been reported by Stout (11), and also, in the Mayo Clinic Reports of 1930 are reports of several recurrences following surgery.

REPORT OF CASES

Case 1. A well developed white girl, 19 years of age, complained of lumpy masses on her left leg. This leg appeared thicker than the opposite one, and marred her personal appearance; otherwise it did not disturb her. At the age of 8 years, she had noticed a swelling on her left shoulder and one on her right wrist. Two years later another swelling appeared on the calf of her left leg and at this time grew quite large, so that it began to worry her. Her past and developmental histories are negative. On physical examination, she showed normal intelligence, was 5 feet 2 inches in height, and weighed 120 pounds. Her heart and lungs revealed no pathologic findings. Laboratory examination of the urine and

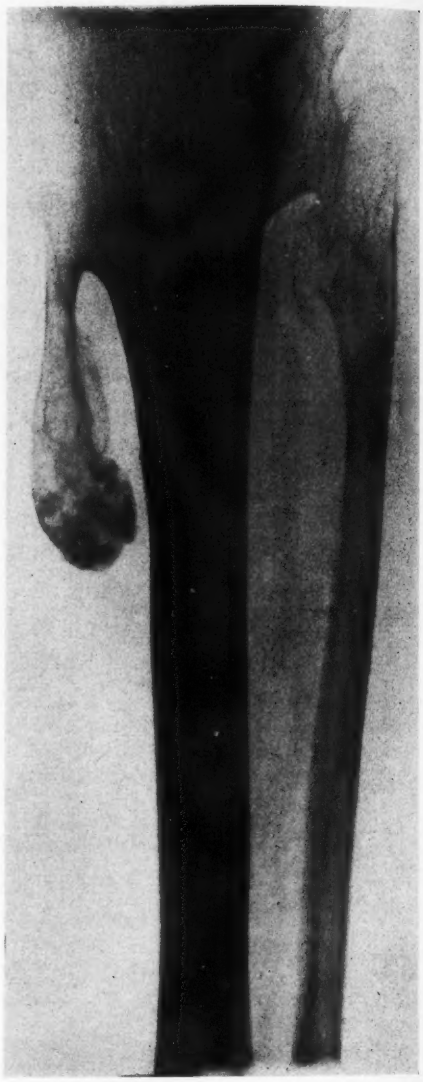

Fig. 8. Case 3. A long bony protuberance was found on the medial surface of the diaphysis of the right tibia.

blood showed normal findings. Her blood Wassermann and Kahn reactions were negative. There was a hard, rough, and bony tumor, the size of an orange, protruding from the postero-medial surface of the left leg just below the knee. The left leg appeared larger than the right one but was not shorter (Fig. 1). There were smaller protuberances on either side of the lower ends of both femora (Fig. 2), but larger on the left side. Small

hard nodules were palpable over the anterior surfaces of the crest of the right ilium and the right hip joint (Fig. 3). All of these were painless and not tender. Roentgenologic examination of the entire skeleton revealed no involvement of the bones of the skull, vertebræ, or ribs. The bony protuberances as described above were distinctly demonstrated as they projected from the diaphyso-epiphyseal region on the long bones. There were areas of rarefaction, with thinning of the cortex, on both tibiæ and fibulæ in the region of the origin of the exostoses (Fig. 2), also a fusion of the lower ends of the tibiæ and fibulæ (Fig. 4). There was a marked bowing of both radii and ulnæ, especially the right, with exostoses at the lower end of the shafts of the radii. The lower end of the left ulna was incompletely developed and partly fused with that of the corresponding portion of the radius (Fig. 5). The patient, however, had not been incapacitated at any time in spite of the marked anatomical skeletal deformities. She refused operation and was in good health three years after this examination. She has moved and we are unable to trace her present whereabouts. Since this is a familial disease we advised a roentgenologic examination of her parents and brother, and they furnish the other two cases reported herein.

Case 2. A white male, 21 years of age, who appeared to be in perfect health and had no complaints. On physical examination no abnormalities were found except that of a bony exostosis on the postero-lateral aspect of the upper third of the right thigh. Roentgenologic examination showed this tumor and also smaller bony exostoses projecting from the diaphyseal region of both femora, with rarefaction and widening of the diaphyses (Fig. 6). Small exostoses were found about the upper ends of both tibiæ and fibulæ, and there was fusion of the lower ends of these long bones (Fig. 7).

Case 3. The father of the above two patients, a fairly well-developed, middle-aged, white male of less than medium height. He has had a swelling on his right leg since his childhood and has paid no attention to it, as it has not disturbed him; moreover, "it ran in his family," since three of his brothers had similar deformities. On physical examination he was shown to be in perfect health. A long bony protuberance was found on the medial surface of the diaphysis of the right tibia (Fig. 8). This diaphysis was noticeably expanded and was partly fused to the head of the fibula. There was a marked curvature of the bones of both forearms, with exostoses at the lower ends of both ulnar bones (Fig. 9). However, he had no functional disturbances in any of his extremities and desired no professional care.

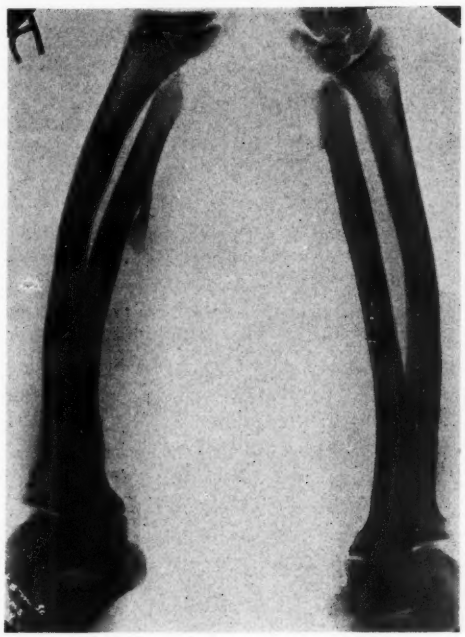

Fig. 9. Case 3. There was a marked curvature of the bones of both forearms, with exostoses at the lower ends of both ulnar bones.

CONCLUSION AND SUMMARY

1. Dyschondroplasia is an hereditary and familial disturbance in the growth of cartilaginous bone tissue, most marked at the diaphyso-epiphyseal junction of the long bones.
2. A review of the literature disclosed much discussion, but the majority agreed that dyschondroplasia, or Ollier's disease, is a form of and synonymous with multiple cartilaginous exostosis and diaphyseal aclasis.
3. The characteristic symptoms and roentgenologic findings of this condition are described.
4. Three cases, with complete roentgen studies, are presented.
5. Evidences of malignant transformation or tendency in dyschondroplasia is rare.
6. Surgical interference is indicated in marked deformities and impaired function.

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A NEW IDEA FOR PORTABLE RADIOGRAPHIC MACHINE[1]

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Portable radiographic work has never been very popular with most roentgenologists, but in certain cases it makes the radiographic examination accessible to the patient who would otherwise have to do without it. Lightness, simplicity, and ease of operation contribute greatly to the success of the work.

A dental machine, which is found in many of the better equipped radiologic departments, with certain adaptations, makes an ideal low-powered portable. I have attempted to show in this paper that these adaptations can be easily arranged without, in any way, distracting from the usefulness of the machine in its intended use. While I would not recommend it for general radiography, still, when operated by a skilled technician, it is quite capable of making good films of any parts of the body except the abdomen.[2]

First of all, the lead wires must be connected to the plugs as shown in Figure 6, and if three different kinds of plugs are used, there is no possibility of the wrong connections being made when the machine is set up. The method of attaching the tube-head to the new stand is shown in Figure 7. Heavy springs in the vertical part of the stand partly counterbalance the weight of the tube-head. There is no need to ground the machine, when used as a portable, unless it comes in contact with the patient, and only then as a precautionary measure, as there is ordinarily no potential on it.

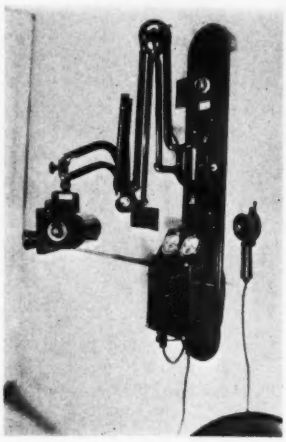


Fig 1. The dental machine.

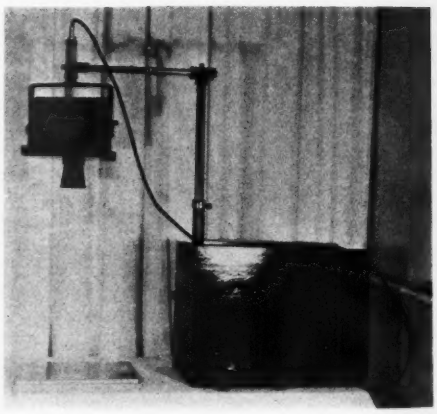


Fig. 2. Machine arranged as a self-contained portable.

Only one difficulty was experienced in this conversion and that came about from the fact that the cover of the timer was grounded to one side of the circuit. This, of course, gave a half-and-half chance of connecting one side of the 110-volt line to the hand of the technician. To eliminate this unpleasant feature, it is necessary to remove this connection from the inside of the timer. The small focal spot of this tube, along with the total absence of the

[1] Read before the Radiological Society of North America at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec.1, 1932.

[2] The illustrations show the method of arranging the carrying-case with the tube stand attached. However, no exact dimensions or instructions are given.

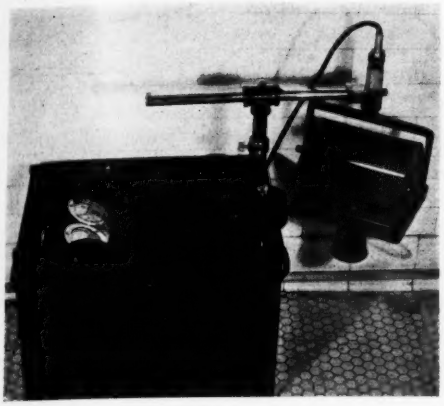


Fig. 3. Top, three-fourths view, showing the way in which transformer is set obliquely in the box when in use, to permit the meters to be more easily read.

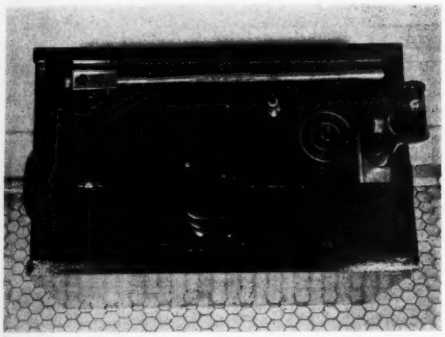


Fig. 4. Packed for transportation but with cover removed.

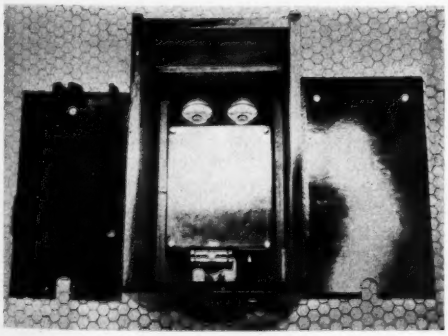


Fig. 5. Showing cover and shelf, which rests on transformer, with felt-padded holders to keep tube-head, timer, etc., from vibrating.

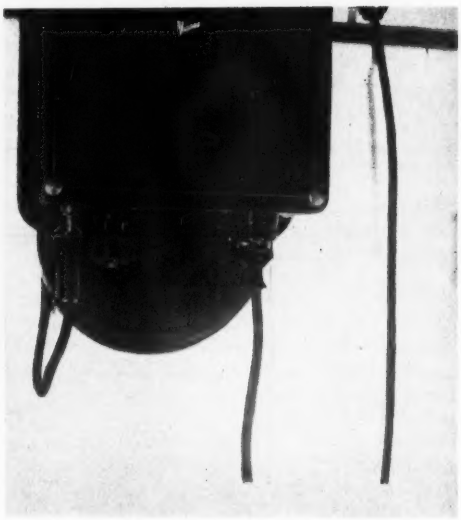


Fig. 6. Plugs on bottom of the transformer. Right, timer plug; middle, main line plug; left, jack to carry current to tube-head.

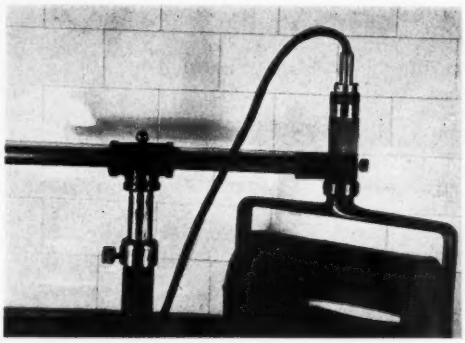


Fig. 7. Details of mounting tube-head. Stud on head passes through the horizontal arm and screws into especially made plug, one side of line (grounded side) entering through the casing, and the other side through spring-plunger in plug.

high tension lines, enables the tube-head to be placed close to the film and, in some measure, makes up for the lack of high power.

It is a great source of pleasure to know that I will no longer have to see films being made with high tension lines weaving in and out of an entanglement of orthopedic apparatus.

105 Rutledge Ave.

MALIGNANCY OF THE ESOPHAGUS, WITH BRONCHIAL FISTULA

CASE REPORTS

By WILLIAM E. ALLEN, JR., M.D., *St. Louis*

From the Departments of Radiology, City Hospital No. 2 and St. Mary's Infirmary

Erosion of the trachea or a bronchus, with the formation of a fistulous tract, is not common; however, it occurred in the two cases herein reported. The picture is characteristic and, once seen, can hardly be misinterpreted. The ingested barium mixture (barium mixture is spoken of because these fistulæ were discovered during the course of a routine gastro-intestinal examination) is seen to leave the esophagus at the point of communication and to enter the trachea or a bronchus. A severe dyspneic and coughing attack follows immediately. The barium is seen in the bronchi both fluoroscopically and on the plates. Of course, in the presence of a known esophagobronchial fistula, the condition is best studied by means of iodized oil.

Case 1. Colored male, aged 49, was admitted on Sept. 25, 1931, complaining of inability to swallow without vomiting. The family history was negative. He admitted pleurisy, syphilis, and several attacks of neisserian infection, having received intensive treatment for the latter two conditions. Although the patient attributed his present illness to his having swallowed a fish bone four weeks prior to his admission, he admitted having been treated at another hospital for six months in 1929 and again for several weeks during 1931 for pains in the epigastrium which migrated to the right hypochondrium. For the past few months he had gradually lost weight and had suffered with anorexia and gastric upsets. Violent attacks of emesis accompanied by expectoration of blood, pus, and mucus had followed every attempt to swallow, even water, for six days before he sought hospitalization.

Physical examination revealed a markedly emaciated adult male lying uncomfortably in left lateral decubitus. There was slight anemia of the mucous membrane. Vocal fremitus was increased over the lower chest. The breath sounds were harshly bronchial in character and whispering pectoriloquy was heard over the left lower lobe.

There were no tender areas or palpable masses in the abdomen, but there was an exquisitely tender spot in the back, at the level of the twelfth thoracic vertebra. The cervical, axillary, inguinal, and epitrochlear lymph nodes were enlarged. There was extreme clubbing of all fingers.

The Wassermann reaction was 2+; blood pressure 128/92; red blood count, 3,200,000; white blood count, 6,100; coagulation time, 4.5 minutes; hemoglobin, 60 per cent; urinalysis disclosed nothing of significance.

A roentgenogram of the chest revealed a marked increase in the peribronchial markings of both lungs, extending well into the periphery and assuming somewhat of a honeycomb formation, a condition which appeared highly suggestive of bronchiectasis. A barium meal was administered and the patient examined under the fluoroscope. There was complete obstruction of the esophagus at the level of the eighth dorsal vertebra; a fistula extended between the esophagus and the left bronchus, and that portion of the esophagus immediately above the obstruction was serrated and of a conical shape (Figs. 1 and 2).

Diagnosis.—Carcinoma of the esophagus, with esophagobronchial fistula.

After an attempt to strengthen the patient by means of intravenous, subcutaneous, and rectal nourishment, a gastrostomy was performed in an effort to prolong life. The patient survived the operation by only 12 hours. Unfortunately an autopsy was not obtained.

Case 2. Colored male, aged 84, was admitted on March 31, 1931, complaining of persistent vomiting and gastric pain. There was nothing of significance in his past or family history. For the previous two years, the patient had complained of gastric disturbances and loss of weight. One month before his admission, he began to suffer with severe attacks of emesis and gastric pain, the attacks occurring about two hours after each meal. For the past week these attacks had been continuous and the vomitus contained large amounts of blood.

Physical examination revealed a very sick, markedly emaciated, adult male, lying in weak, dorsal decubitus. His tongue was heavily coated and his breath foul. Fine crepitant râles over both lungs and a friction rub over the left base were elicited. The heart was slightly enlarged to the left. No distention or palpable masses were noted in the abdomen, but there was marked rigidity and tenderness in the epigastrium. The back and extremities were negative except for the previously mentioned emaciation.

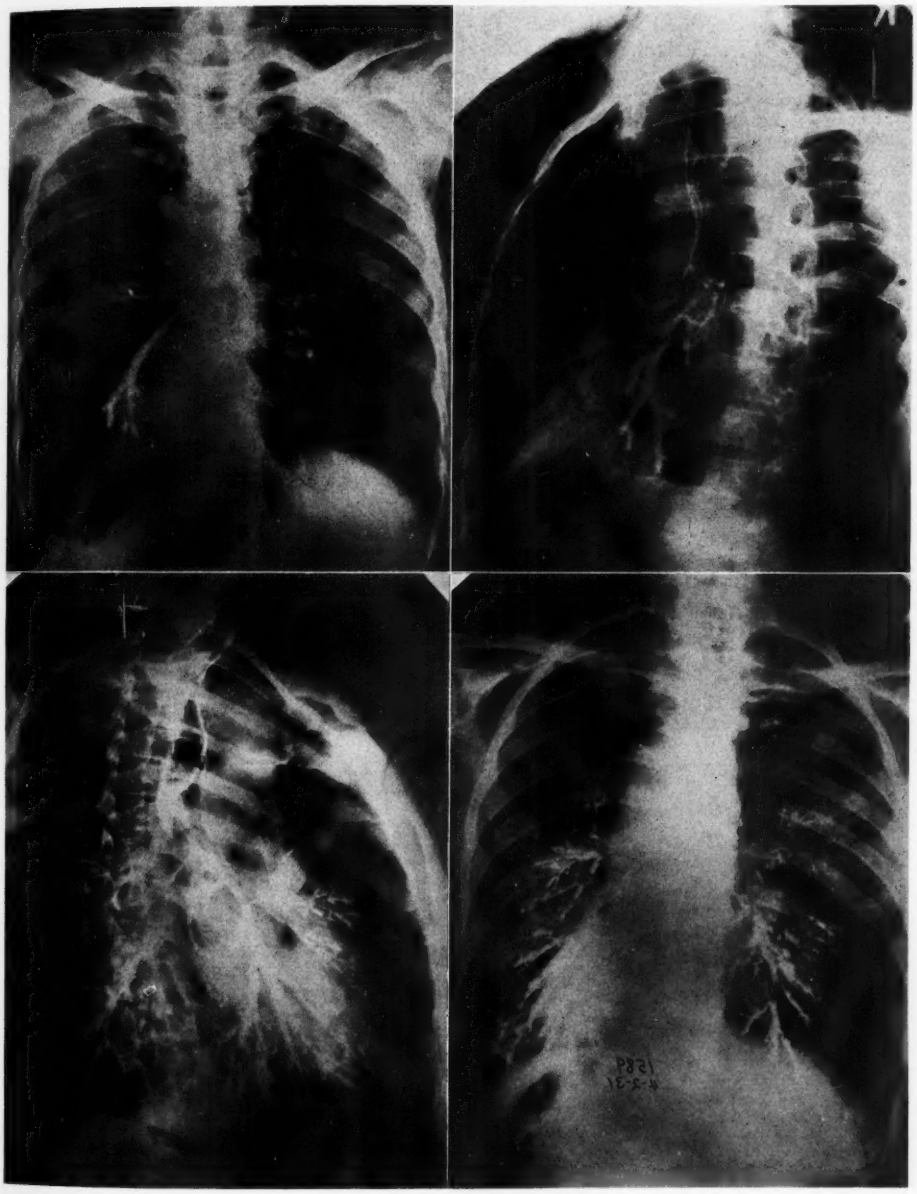
The blood pressure was 150/80; white blood count, 10,500; hemoglobin, 70 per cent; no abnormal urinary findings.

Roentgenographic and roentgenoscopic examination of the gastro-intestinal tract revealed a fistula of the esophagus with the bronchi, through which the barium entered the middle and lower lobes. The esophagus

was not visualized below the level of the seventh dorsal vertebra. No barium entered the stomach.

Roentgenographic examination of the chest revealed extensive involvement of both lungs by infiltration, and areas of consolidation. The bronchioles of the middle and lower lobes were visualized by the barium from the fistula with the esophagus (Figs. 3 and 4).

Diagnosis.—Carcinoma of the esophagus, with rupture into the bronchi; pulmonary abscess.



Figs. 1 and 2 (*above*). Case 1. Cancer of esophagus.
Figs. 3 and 4 (*below*). Case 2. Cancer of esophagus, with fistula into bronchus.

The patient rapidly grew weaker and died on the fourth day after admission.

At autopsy the lungs were found to be covered with a heavy black deposit and, upon section, exhibited the previously aspirated barium sulphate. The bronchial glands were enlarged to the size of a hickory nut and showed a dark bluish color upon section. Just at the bifurcation of the trachea, the esophagus consisted of a hard, nodular, partly eroded mass about the size of the fist. On splitting this mass, a false tract leading into the left bronchial tube was revealed. The esophagus for about two inches, extending between the area of involvement and the cardiac end of the stomach, was free of pathology. The stomach was dilated and the walls were very thin. At the cardiac end, on the posterior wall, there was a cup-shaped depression, the size of a quarter-dollar, with elevated borders. The tissues around the depression were infiltrated with nodular growths. After microscopic study of a section taken from the involved area of the esophagus and trachea, the pathologist, Dr. C. W. Scherry, reported a small round-cell sarcoma.

AN UNUSUAL CASE OF FOREIGN BODY IN THE BRONCHI

By H. E. KIMBLE, M.D., *Chicago*

A white boy, 7 years of age, was brought into the office, complaining of pain in his abdomen. The father stated that four weeks previously the child choked on a whistle. His mother became frightened and pushed her finger down the child's throat, after which he appeared to be all right. No more was thought about the whistle until the child began to complain of cramps in his lower abdomen. During all this time the boy had been well with the exception of an occasional harsh dry cough. Fear that the whistle caused the child's distress impelled the parent to bring him in for examination.

No definite findings were elicited on physical examination.

Fluoroscopic examination of the abdomen was negative; in the chest, however, a foreign body was observed in the superior branch of the right bronchus (Fig. 1).

Bronchoscopic examination was advised and made later in the day. No foreign body was found, though, on fluoroscopic examination, it was seen in the same position. The following morning an x-ray plate was made of the patient's chest, revealing the foreign body in the inferior branch of the left main bronchus (Fig. 2). The hospital nurse reported that the patient had had one or two severe coughing spells during the night.

On subsequent bronchoscopic examination the foreign body was easily located but was removed only after repeated attempts. It proved to be a tin reed about 0.8 cm. × 2 cm., out of a toy whistle. The child made an uneventful recovery.

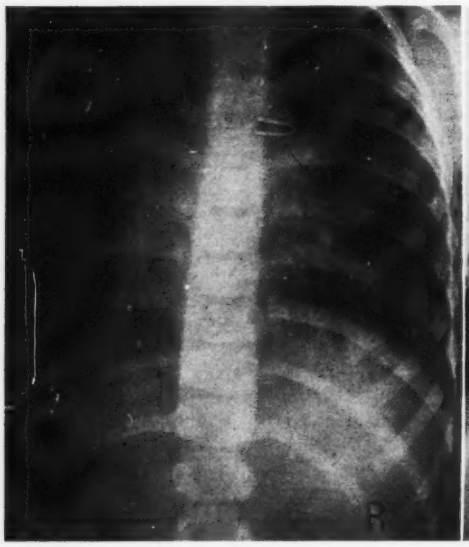


Fig. 1. Location of foreign body at time of admission of patient to hospital.

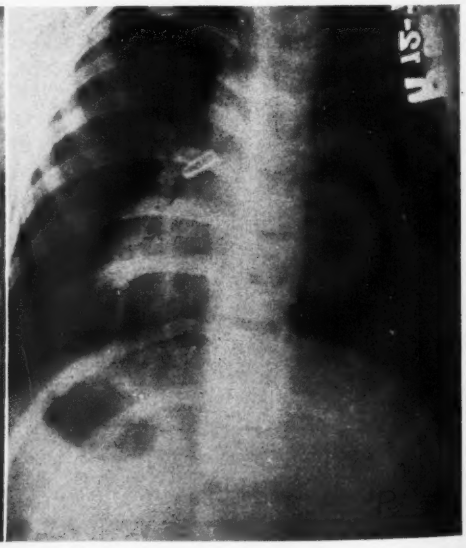


Fig. 2. Location of foreign body at time of its removal.

CONCLUSIONS

1. A foreign body which does not completely obstruct a bronchus may be present for a long time without producing symptoms.
2. A foreign body can be coughed up by the patient and re-inhaled.
3. Foreign bodies can change their position in the lungs.

7854 S. Ashland Ave.

CAVERNOUS HEMANGIOMA OF THE LEG[1]

By WILLIAM H. TELLER, M.D., LEON SOLIS-COHEN, M.D., *and* SAMUEL LEVINE, M.D., *Philadelphia*

The reason for reporting this case is its relative infrequency and the puzzling roentgenologic aspects as to whether the tumor mass, as observed on the film, sprang from the periosteal bone layer or secondarily involved bone.

The patient was a white female, aged 63 years. To use her own words, the growth began 22 years ago, as a "small hole in the left leg, which alternately would heal over and break down again." Ten years ago it began to grow and amputation of the limb was advised, but refused. It has grown steadily larger, and the leg is painful when the patient is walking. The tumor bleeds readily and on one occasion there was a distinct hemorrhage. Otherwise, the previous history of the patient has no bearing. Spinal and blood Wassermanns are negative. Complete blood count is normal.

There is a large tumor mass (Figs. 1 and 2), ulcerating and cirsoid in type, springing from the soft tissue of the left leg on the anterior aspect. The tibialis anterior is the muscle involved.

Radiographic Appearance.—There is a large nodular, cirsoid oval tumor mass in the anterior aspect of the lower third of the left leg, which extends posteriorly into the interosseous space. There are two or three small bone spicules lying at right-angles to the shaft of the tibia and penetrating the growth. The periosteum is proliferated and elevated along the anterior aspect of the tibia, and the cortex is thickened. There is no invasion of the medullary canal nor any breaking down of the cortex of the tibia. There is sclerosis of the cortex in the region of the head of the tibia along the inner aspect of the head and neck. The fibula shows definite periosteal reaction and proliferation along both borders of the shaft. There is decalcification of the shaft of the fibula. In the neck of the fibula is a small circular area of bone rarefaction, with a calcific border suggesting an old healed cyst.

[1] Reported from the service of William H. Teller, M.D., Jewish Hospital, Philadelphia.

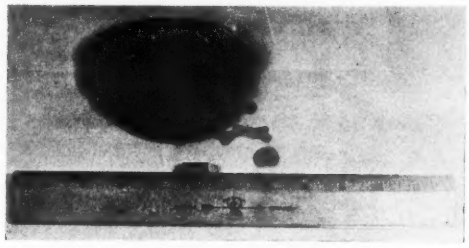


Fig. 1. Specimen, showing relative size.

We thought that a tumor arising from the bone was definitely excluded and that a periosteal origin of the tumor, a simple fibroma, or one undergoing sarcomatous change, was the most likely diagnosis. The appearance of the mass definitely excluded syphilis and osteogenic sarcoma. As in this case, the diagnosis is seldom made before operation.

Operation.—Using a tourniquet above the tumor, the entire growth was removed by Dr. Teller. Moderate hemorrhage was encountered. The underlying periosteum was removed with the growth.

Macroscopy.—The specimen consists of a segment of tissue measuring 9.5 × 7.5 × 3 centimeters. Superficially it is a cauliflower growth—an ulcerating, fungating, irregularly shaped mass having an elliptical edge. On cross-section several hemorrhagic cyst-like spaces are noted, the edges of these areas being indurated and necrotic. Grossly, the tumor was an integral part of the tibialis anterior muscle, being attached to the periosteum of the tibia. A small spicule of bone projected from the tibia into the substance of the growth. The tumor is permeated throughout by variously shaped and sized cavities filled with either hemorrhagic or slate colored semi-gelatinous material. A portion of the periosteum and the underlying bone is also present, the former considerably hypertrophied and thickened. No bone involvement by the tumor is seen.

Microscopy.—A section of tissue is lined by squamous stratified epithelium, sharply outlined. The subepithelial layers show areas composed of numerous capillaries. Some of the spaces are sponge-like in appearance, while other vascular spaces are sacculated, and some of the blood channels intercommunicate. Considerable necrosis is present, and secondary infection. Many polymorphonuclears and plasmacytes are noted, together with old hemorrhagic extravasation and blood

Fig. 2. Gross appearance of the lesion.

pigment. There is considerable fibrosis noted throughout. Some sections of the tumor present rapid cellular proliferation, some of the individual cells being spindle-shaped, though they do not show hyperchromatism. Certain fields show widespread areas of muscle undergoing Zenker's degeneration. In longitudinal section, the muscle fibers have lost their striations, while in cross-section, nothing is left of muscle fibers but the sarcolemma and the nuclei, so that they simulate giant cells. Numerous cavernous spaces and capillaries have worked their way into the muscle, some

Fig. 3. Roentgenograms of cavernous hemangioma of muscle. Observe soft-tumor shadow, spicule of bony attachment, and periosteal reaction of tibia and fibula.

of the latter showing proliferative change, and clusters of foam cells are occasionally noted.

Discussion.—In a recent article H. R. Jenkins and P. A. Delaney reviewed 255 cases of benign angiomatous tumors of muscle, and reported one additional case. We are reporting the two hundred fifty-seventh case in the literature because of some unusual and uncommon clinical and radiographic features. No history of trauma was elicited in this case. It began in the fourth decade although the patient is now in the sixth. In addition to various theories of origin, all of which are speculative or theoretical, Jenkins and Delaney feel that a congenital factor plays an important etiologic rôle.

There are three types of hemangioma: a diffuse type, a partially circumscribed type, and a circumscribed type. Our case was diffuse, adherent to the periosteum, the overlying

skin was necrotic, and the whole mass had a foul odor.

Out of the 256 previously reported cases, in 39 a leg was involved. The size varies from that of a bean to that of a child's head. Ulcerated and necrotic skin is rare, over 50 per cent showing normal skin and the rest are variously discolored.[2]

Diagnostic Point.—Of these tumors, 79 per cent appear during the first twenty years and 94 per cent during the first thirty years.

Forty-two per cent of them are located in the lower extremities.

The tumor mass is usually painless at first, but pain occurs in about 58 per cent during the course of the disease.

Some functional impairment or deformity occurs in about a fourth of the cases.

When blood is aspirated in an exploratory puncture of the tumor, it is of considerable importance in establishing a correct diagnosis. X-ray examination may help in making the diagnosis, particularly if phleboliths are found.

With regard to the x-ray findings, it is noteworthy of comment that in two cases only has a soft tissue shadow been cast by the tumor. Because of the size and the suspicion of malignant degeneration, irradiation therapy (1,800 r) was given to the tumor site without any change being observable.

Differential Diagnosis.—The most common pre-operative diagnoses have been: lipoma, neuroma, neurofibroma or fibroma, sarcoma, and dermoid cyst. Our diagnosis was fibroma or fibroma undergoing sarcomatous degeneration.

Prognosis.—No report of mortality following or previous to operation has been found. Recurrence was reported 15 times, mostly after incomplete excision.

SUMMARY

A case of benign angiomatous tumor of the leg is reported, with a roentgen summary. The etiology of the type of tumor is still unknown, though observers believe that both a congenital and a traumatic factor are of importance. The correct diagnosis is seldom made before operation, but phleboliths on the x-ray film are significant. Other diagnostic signs are periosteal reaction in the bones of the part in which the tumor arises, demineralization of the bones, increase or decrease of surface temperature, evidence of interference of circulation, presence of a slow-growing mass involving muscle, and aspiration of blood from the tumor.

[2] For a complete analysis of cases reported the reader is referred to Surgery, Gynecology and Obstetrics, October, 1932.

We are dealing here with a cavernous muscle hemangioma. In spite of the chronicity of the tumor, we are inclined to believe that this neoplasm will recur locally or show evidence of metastasis in the future. This conclusion is drawn from the fact that cellular proliferation is very active.

IODISM FOLLOWING ORAL ADMINISTRATION OF GALL-BLADDER DYES

By KENNETH S. DAVIS, M.D., *and* S. GORDON ROSS, M.D., *Los Angeles, Calif.*

From the X-ray Laboratory, St. Vincent's Hospital

During the earlier period of the development of cholecystography, reactions were frequent and occasionally of an alarming nature. However, since the introduction of tetraiodophenolphthalein and especially phenoltetraiodophthalein it is seldom that one encounters a reaction of serious consequence.

Graham, Cole, Copher, and Moore report that in 85 per cent of their cases there is little or no reaction to the intravenous administration of gall-bladder dyes. Mild reactions reported in the literature following intravenous gall-bladder dyes consist of vertigo, headache, backache, nausea, weakness, and urticaria. Among the more severe reactions are included the following: severe nausea, vomiting, chills, circulatory depression, fever, and severe abdominal cramps. Following the oral administration, the usual reactions encountered are nausea, vomiting, diarrhea, and abdominal cramps. The factors influencing reaction are: first, the freshness of the preparation; second, the susceptibility of the patient, and third, the amount of the dye substance given.

The contra-indications to cholecystography generally mentioned in the literature are cardiac decompensation and jaundice, especially if the latter is due to acute liver infection or to common duct obstruction. It has also been observed that patients with an abnormally high or low blood pressure are more susceptible to reaction than patients with blood pressure near the normal limits. Graham and Cole state that threatened uremia is a contra-indication to cholecystography. In a survey of the literature we were unable to find any recorded cases of iodism following the use of gall-bladder dyes.

CASE REPORT

A male patient, 57 years of age, was referred to the x-ray laboratory at St. Vincent's Hospital on Oct. 22, 1932, for a gall-bladder dye study. He had been complaining for the past

five years of constant stomach trouble which came on particularly after taking fried foods, fats, rich food, onion, cabbage, etc. His chief complaint was distention and gas; there was very little belching or nausea, and no vomiting. Bowels were constipated; stools were unusually light and at times clay-colored. A previous gastro-intestinal examination had failed to reveal evidence of intrinsic organic involvement of the gastro-intestinal tract. Patient was not jaundiced. He was given a prescription for a one-ounce bottle of a well-known brand of gall-bladder dye emulsion. Following directions, he had a fat-free evening meal and at 7 P.M. took the contents of the bottle in four ounces of Welch's Grape Juice. Three and one-half hours after taking the emulsion, the patient became very apprehensive when he experienced difficulty in breathing and pain in the back of the head. He developed a burning sensation in the mouth and throat as though he had swallowed red pepper. The tongue was so enlarged that it filled the mouth, making speech and swallowing impossible. The lips were swollen and the adentious alveolar processes were ten times their normal size. The submaxillary glands were swollen to the size of a small hen's egg and, by 3 A.M., were very tender. The parotids were enlarged, resembling a bad case of mumps. There was marked puffiness around the eyes and severe occipital headache. Salivation was marked and very annoying, due to the loss of function of the tongue and lips. The salivary glands remained swollen for several days). Subsequent examination revealed no constitutional condition or metabolic deficiency to account for this reaction. The blood and urine were normal. Iodism in this case was manifest only in the salivary glands and buccal contents. There was no skin manifestation seen during the illness.

Correspondence with the Company manufacturing the dye shows that it was made on Sept. 14, 1931, over one year prior to its use. The patient stated that he had had a gall-bladder dye study made three years before, without marked reaction.

Comment.—The most commonly reported symptoms of iodism are the skin eruptions and varying degrees of catarrhal involvement in the respiratory tract, with severe gastro-intestinal disturbances as a frequent accompaniment. Solutions and compounds containing large percentages of iodine are used extensively in therapeutics or as opaque substances for radiography of the cerebral and spinal spaces, gall bladder, urinary tract, uterus and tubes, sinuses, and bronchi. Such preparations are potential sources of iodism.

Firth reports a case of iodism following the introduction of 30 c.c. of chloriodized peanut oil (a small portion of which was swallowed) into his bronchi. His symptoms were strikingly similar to those observed in our case. Iodism following the use of gall-bladder dye may be experienced unless great care is observed in its administration and a strictly fresh preparation used. Had our patient been given the dye substance intravenously, the reaction would undoubtedly have been more severe and might have resulted fatally.

SIXTY-TWO CASES OF HERPES ZOSTER SUCCESSFULLY TREATED WITH X-RAYS[1]

By JOHN M. KEICHLINE, M.D., *Huntingdon, Pennsylvania*

It is now safe to regard the peculiar eruption of herpes zoster as being in every case the trophic expression of inflammation of the corresponding ganglion of the posterior root, whether spinal or cranial. Etiology of the idiopathic form is not known, but Teague and Goodpasture's hypothesis of the *modus operandi* is as good as any, and the toxic, secondary, and infectious causes as seen in gout, adjacent organic disease, and meningitis are known to all clinicians.

Herpes zoster has been treated with x-rays as a dermatitis, with about the same degree of success as attends upon other therapy—superficial and symptomatic treatment may ameliorate but will not abort or shorten the course of an inflammation of a posterior root ganglion.

Among the first cases treated were members of our hospital staff. Our internist sought relief from severe pain in his right chest and upon examination, we found he had the first bouquet of herpes zoster over the sensory fibers. He was given 148 r through 3 mm. aluminum at a 30-cm. distance over the eruption and to the corresponding root ganglion. In a few hours the pain was relieved and the next morning he reported that only a slight trace of the original eruption could be seen and no new bouquets had formed. All patients seen in the early stage responded in like manner, except 8 per cent, who were given a second dose the following day for pain.

Of the cases seen, 2 per cent were post-paralytic. The following cases will illustrate the results.

Case 1. Male, aged 82, was referred on account of pain in the left forehead and side of the face. Four weeks previously he had had

[1] Read before the American Congress of Radiology, at Chicago, Sept. 25–30, 1933.

herpes zoster, which cleared up as far as the eruption was concerned but at the time of examination he had a feeling of tightness of the skin, could not raise the eyebrow, and had been having constant neuralgia that was not again given 148 r, which relieved the pain and checked the eruption. However, in ten days he returned with pain and herpes showing on the buccal membrane. Again the pain and eruption subsided, but he was left with a

Fig. 1. Roentgenogram showing forearm with foreign body (knife blade).
(See page 374.)

relieved by analgesics. He was given 148 r over the Gasserian ganglion at intervals of ten days, and after the third dose had completely recovered.

Case 2. This most interesting case was that of a man, aged 70, who was referred on account of excruciating pain over the distribution of the fifth cranial nerve, with herpes zoster in front of and below the ear. He was given 148 r, following which therapy he was comfortable for ten days and the eruption disappeared. There was a recurrence of pain, with herpes in the aural canal and on the drum. He was paralysis of the left side of the face and an internal squint. These conditions disappeared in a few weeks and by the seventieth day recovery was complete.

The ages of the cases in the series reported were from 5 to 82 years. Males constituted 90 per cent. Half of the cases were due to inflammation of the thoracic posterior root ganglion; 10 per cent were cervical, 13 per cent lumbar, 10 per cent sciatic, and 17 per cent cranial. Onset was quite evenly distributed throughout the year. In treating, 90 per cent received only one dose of x-rays,

8 per cent were given a second dose the following day, and the 2 per cent of recurrent and post-paralytic cases were treated every ten days. In all of them, three doses were sufficient.

UNUSUAL FOREIGN BODY IN FOREARM

By GEORGE K. NUTTING, M.D., *Washington, D. C.*

From the Surgical Department of Georgetown University Hospital

A colored truck driver, aged 29 years, came to Georgetown Hospital complaining of a sore arm. Three days before admission to the hospital, a packing case fell from the truck and struck his arm. His history otherwise was negative, except that he said he had been in an automobile wreck five months before, at which time his arm went through the windshield and the bleeding was so severe that it was necessary for the doctor to operate to stop the hemorrhage.

Examination of the forearm showed an elongated semicylindrical swelling over the middle third of the radial side of the extensor surface. The swelling was very tender to the touch and a long hard object could be palpated deep under the skin. X-ray films revealed a knife blade situated as shown in Figure 1. (See page 373.)

Under local anesthesia, a Russell stainless-steel knife blade was found embedded in firm, dense, fibrous tissue. When removed, the blade measured three inches in length.

This case is unusual and interesting in that the patient pursued a laborious occupation with such a large foreign body in his forearm.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

THE EVOLUTION OF THE ROENTGEN CRITERIA IN ADULT PULMONARY TUBERCULOSIS

From time to time, in our onward march of progress in roentgenology, it behooves us to stop to consider briefly the steps we have taken to arrive at our present state of knowledge. Some of these steps are due to improvements in mechanical equipment and in technic, but many are the result of painstaking experimental and clinical studies by the early workers. In the early day of roentgenology, observations were made in pulmonary tuberculosis despite the technical difficulties involved.

In the earliest reports on chest examinations the fluoroscope occupied the preëminent position, probably because of the technical difficulty in producing a diagnostic plate. On Oct. 1, 1896, in the "Boston Medical and Surgical Journal," Francis H. Williams[1] reported as follows: "I have examined about forty cases of pulmonary tuberculosis, and find not only that the fluoroscope is of value in determining the extent of the disease, but also sometimes reveals its location where and when it would otherwise have been unsuspected." In 1903 the same author states that, "While the x-ray photographs show clearly that the lungs are denser than normal when the disease has passed the very earliest stage, thus far I have been able to detect an abnormal condition of the lungs in early tuberculosis better by means of the fluorescent screen than by means of the photograph. The screen is a readier and more certain test."

The principal fluoroscopic findings which he recorded were a dark shadow due to increased density, and a restriction of the diaphragm on the affected side, usually in the lower part of its excursion.

The radiographic part of the examination was facilitated by the work of Hulst,[2] who, in 1902, produced the first lung roentgenograms made in America in one second without the aid of intensifying screens. As the technical difficulties in radiography were gradually solved the fluoroscope lost its preëminent position and as early as 1906 Pfahler[3] warned of the danger of fluoroscopy. He also felt that it was inaccurate and not necessary.

From this time on, the search for positive radiographic evidence of tuberculosis occupied the center of the stage. Much was written and many roentgen signs were described, but it remained for Cole[4] to insist upon the visualization of the tubercle, or conglomerate tubercle, as the earliest positive manifestation of pulmonary tuberculosis. He states that these earliest changes are the intermediate sized tubercles, the smallest ones that are clearly discernible to the naked eye on cross-section of the lung. "It is on these tubercles that the positive diagnosis of incipient pulmonary tuberculosis by the x-rays depends."

Dunham,[5] in 1916, described fan-shaped densities in the lung near the pleura. He stated that they were due to masses of tubercles and took their shape from the anatomy of the portion of the lung involved and not from the shape of the tubercles. This is essentially an area of lobular pneumonia due to an early infection of one or more lobules. Exudation accompanying the infection produces most of the hazy shadow seen in early lesions. The work of Cole and Dunham has been provocative of much critical discussion, but their work remains to-day as two of the guide posts that direct our course in the diagnosis of pulmonary tuberculosis.

The roentgenologic diagnosis of the adult form of pulmonary tuberculosis rests upon the visualization of conglomerate tubercles, the accompanying exudate, fibrosis, and calcification, depending upon the stage and activity of the lesion at the time seen. It may not be possible to visualize the conglomerate tubercle because of surrounding exudate, but when seen in the subapical area it is a very positive aid in diagnosis. In a sensitized person, exudation about the focal lesion may be the earliest roent-

[1] F. H. Williams: The Roentgen Rays in Medicine and Surgery. Third edition. Macmillan, New York, 1903.

[2] H. Hulst: Trans. Am. Roent. Ray Soc., 1903.

[3] G. E. Pfahler: Jour. Am. Med. Assn., XLVI, 23.

[4] L. G. Cole: Am. Jour. Med. Sci., CXL, 29.

[5] Kennon Dunham: Am. Jour. Roentgenol., IV, 280.

gen finding. This exudation, beginning in a secondary lobule of the lung, is limited by the interlobular septa, unless cavitation occurs. It produces the fan- or cone-shaped shadow described by Dunham. Unfortunately, these fans may be seen in other diseases such as influenza, pneumonia, and pneumonoconiosis. If they occur in the apical region and persist, there is a strong probability that they have a tuberculous etiology.

Fibrosis is indicative of an older lesion and shows evidence of partial or complete healing, the stage of which, in most instances, must be determined by clinical methods. Calcification denotes an older, healed process but does not rule out activity immediately adjacent. A safe rule is not to diagnose activity from the roentgen examination alone.

The term "peribronchial tuberculosis" has occupied a prominent place in the literature for many years. By this term was meant accentuation of the linear markings, often accompanied by studding or beading. Various authors advanced criteria by which these changes could be differentiated from the markings seen in normal individuals, but they have not stood the test of time. Pancoast,[6] in 1917, recognized this term but added that without tubercle bacilli this roentgenographic appearance cannot *per se* be regarded as indubitable evidence of a tuberculous etiology. Fales,[7] in 1926, stated that roentgenographic peribronchial infiltration is of no importance as pulmonary tuberculosis. It was not associated with tubercle bacilli in the sputum of any of his cases. Amberson,[8] after thoroughly covering the literature on the subject, in 1927, concluded that a diagnosis of peribronchial tuberculosis should not be reported, but that some term such as "peritruncal thickening" could be employed "in a descriptive sense to convey to the mind the idea of structural change, represented by accentuated and prolonged linear markings, with or without beading."

Just as incipient pulmonary tuberculosis can be detected roentgenographically earlier than by clinical methods, so will many cavities be visualized on the roentgenogram when they escape detection by physical examination. Amberson[8] has aptly stated that, "with the advent and perfection of the roentgen ray, however, few of these lesions should escape us because, while sometimes 'silent,' they are rarely invisible." The recognition and changing features of pulmonary cavitation in the ordinary sense need no exposition to roentgenologists. Certain thin-walled circular shadows, which received the name of "annular shadows," evoked much discussion after their description by Sampson, Heise, and Brown,[9] who believed them to be due to localized spontaneous pneumothoraces and, therefore, relatively harmless. Amberson[10] believed some of these to be caused by localized pleurisy. Doub[11] demonstrated by films and autopsy specimens that certain of these shadows are due to emphysematous blebs. These, however, are more likely to occur in the bases.

The work of Burnham and Brown[12] and Dunham and Norton[13] has demonstrated quite conclusively that not only may cavities have thin walls and show very little infiltration about them, but that they may appear and disappear with relative quickness. There is every probability that circular shadows occurring in conjunction with pulmonary tuberculosis are true cavities and only in rare instances can they be attributed to pleural lesions.

The scope of this communication does not permit a complete exposition of the roentgen findings in the various manifestations of pulmonary tuberculosis, nor the relation of the pleural reaction, the apical cap, and other associated conditions. Most of the discussion above has to do with the original diagnosis of the pulmonary lesion. In addition to this, the roentgen examination is unexcelled in noting the progress of the lesion under treatment. From the basic concept, that rest of the involved part is the greatest aid in healing, has evolved the more recent collapse therapy. By this is meant such procedures as artificial pneumothorax, paralysis of the diaphragm from surgery upon the phrenic nerve, and thoracoplasty, which procedures have made progressive roentgen examinations of paramount importance in judging the amount of collapse, the effect on the lesion and the opposite lung,

[6] H. K. Pancoast: Am. Jour. Roentgenol., IV, 462.

[7] L. H. Fales: Am. Jour. Med. Sci., CLXXII, 382.

[8] J. B. Amberson: Am. Jour. Roentgenol., XVII, 557.

[9] H. L. Sampson, F. H. Heise, and L. Brown: Am. Rev. Tuberc., II, 664.

[10] J. B. Amberson: Am. Jour. Roentgenol. and Rad. Ther., XII. 438.

[11] H. P. Doub: Am. Jour. Roentgenol. and Rad. Ther., XX, 6.

[12] M. P. Burnham and P. K. Brown: Am. Rev. Tuberc., VI, 469.

[13] H. K. Dunham and V. V. Norton: Am. Rev. Tuberc., X, 306.

and any untoward changes in other structures. Douglas[14] states that collapse therapy is the greatest advance yet made in the treatment of pulmonary tuberculosis, and that it would be impossible to carry out such treatment satisfactorily without the aid of the roentgen ray.

In the review of this subject we have been able to refer to only a few of the excellent contributions on this subject. It may be stated in general that, in many early cases, the roentgen examination may give the only evidence of disease. Activity or non-activity should not be decided from this examination alone; many so-called "silent" cavities will be seen which are not discoverable by other methods, and a proper appreciation of normal shadows is absolutely necessary in the diagnosis of chest roentgenograms.

It is a far cry from those early days of roentgenology when most clinicians looked with suspicion upon the attempt to diagnose pulmonary tuberculosis in cases which were negative to the usual clinical methods of diagnosis, to recent statements of Lawrason Brown,[15] as follows: "To refuse to accept this evidence places upon those who assume such an attitude the same responsibility as fell upon those who refused to accept the importance of the tubercle bacillus or of hemoptysis or of pleurisy, with or without effusion, in the diagnosis of pulmonary tuberculosis. . . . We are in a new era in regard to the diagnosis of pulmonary tuberculosis and whether the value of the roentgen examination is accepted now or postponed for a decade or longer, the diagnostician and roentgenographer will eventually have to modify their practice and their technic to conform with it."

HOWARD P. DOUB, M.D.

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[14] B. H. Douglas: Am. Jour. Roentgenol. and Rad. Ther., XXX, 305.

[15] Lawrason Brown: Am. Jour. Med. Sci., CLXXIIX, 700.

COMMUNICATIONS

THE AMERICAN BOARD OF RADIOLOGY

The need for improved standards in the various medical specialties has become increasingly apparent during the past twenty years. Specialism is necessary in medical progress but evils have attended its development in this country, the worst of these being the assumption of the title "specialist" by men with inadequate training and experience. Methods of licensure for the practice of medicine in this country are so complicated, being under 49 different jurisdictions, that it has never seemed feasible nor advisable to attempt to bring specialists under legal control beyond that required by their license to practise medicine. Several of the specialties have attempted to bring about a measure of control and improvement within their own special fields by establishing examining boards to certify to the qualifications of specialists in their own branch of medicine. Particular credit is due to the pioneer board in ophthalmology which was organized in 1916, and to its Secretary, Dr. William H. Wilder, for assistance in the formation of succeeding boards in other specialties. After several successful years of operating the original Board of Ophthalmology, boards were formed successively for otolaryngology, obstetrics and gynecology, dermatology and syphilology, and for pediatrics. Radiologists wish to record their appreciation for the help and inspiration that they have received from the secretaries of all the established boards.

The desirability of instituting a board for radiology had been discussed for several years among radiologists, and the matter was brought to a head at the meetings of the American Medical Association and the American College of Radiology held in New Orleans, in 1932. At that time, committees were appointed by the College of Radiology and the Section on Radiology of the American Medical Association to investigate as to the advisability of forming such a board. At the suggestion of the Council on Medical Education and Licensure of the American Medical Association, this matter was brought to the attention of the American Roentgen Ray Society, the Radiological Society of North America, and the American Radium Society at their annual meet-

ings, and each of these societies likewise appointed a committee to investigate the advisability of forming such a board.

The committees representing these five radiologic organizations met on June 11, 1933, in Milwaukee, during the meeting of the American Medical Association. They effected a preliminary organization and adopted the following recommendations to be presented to each of the five associations represented:

(1) "That it is the sense of this joint committee that a national examining board for radiologists be formed;

(2) "That it be recommended to each of the five societies here represented that three members be appointed by each of the societies to constitute a national examining board for radiology;

(3) "That the purpose of the Board shall be the examination and certification of radiologists;

(4) "That the Board thus formed be authorized to effect its own organization, elect officers, adopt rules of procedure, and proceed to the examination and certification of candidates."

The above recommendations were approved by each of the societies, namely, the American College of Radiology, the American Roentgen Ray Society, the American Radium Society, the Radiological Society of North America, and the Section on Radiology of the American Medical Association. Three members were appointed from each of the societies to form the Board.

The organization meeting of the Board was held at the Palmer House, in Chicago, on September 28, 1933, during the first American Congress of Radiology, and H. K. Pancoast, M.D., was elected President of the Board and B. R. Kirklin, M.D., Secretary-Treasurer. A committee consisting of W. F. Manges, M.D., A. C. Christie, M.D., and John W. Pierson, M.D., was appointed to draw up by-laws and secure the incorporation of the Board.

The Board met again in Washington, D. C., on January 27 and 28, 1934, at which time by-laws and articles of incorporation were adopted. The following permanent officers were elected: H. K. Pancoast, M.D., President, A. C. Christie, M.D., Vice-president, and B. R. Kirklin, M.D., Secretary-Treasurer.

The purposes of the Board according to the by-laws are as follows:

"(*a*) To elevate the standards and advance the cause of radiology by encouraging its study and improving its practice;

"(*b*) To test the qualifications of those who profess to be specialists in radiology by arranging and conducting examinations of voluntary applicants for the certificate of the Board, and to issue certificates to those found qualified therefor;

"(*c*) To prepare and maintain a registry of holders of the certificate of the Board;

"(*d*) To serve the public, physicians, hospitals, and medical schools by furnishing lists of those who have received the certificate of the Board and thus to assist in protecting the public against irresponsible and unqualified practitioners who profess to be specialists in radiology."

The rules of the Board require that applications for certificates be made upon a prescribed form to be secured from the Secretary.

Each applicant must establish, to the satisfaction of the Board, that he is of high ethical standing; a graduate of a medical school approved by the Board; a member of at least one of the societies which appoint members of the Board; has had satisfactory experience in the practice of radiology, and that he is a physician duly licensed to practise medicine.

The by-laws of the Board provide that "each applicant for the certificate of the Board shall be examined in such manner and under such rules as the Board may prescribe, due weight being given in each individual case to professional attainments, years of training and practice, teaching and other positions held." It will be understood from this that the Board intends to fix the extent and the scope of the examination in each individual case. The successive steps in a *complete* examination are as follows: (1) Submission to the Secretary of the prescribed application form properly filled out; (2) submission to the Secretary of reprints or original thesis; (3) personal appearance before the Board for oral and practical examination.

The candidate will be informed after each successive step what is further required of him.

The experience of the Boards already functioning has been very satisfactory, and it is the general opinion that they have served to improve conditions in each specialty represented. Based upon their experience, the following advantages may be expected from the

functioning of the American Board of Radiology:

1. Certification by the Board furnishes a criterion to both lay and professional groups for judging a radiologist's qualifications.

2. Hospitals and other organizations will gradually establish rules limiting service on their staffs to those certified by the Board.

3. It will gradually tend to limit specialization to those who are qualified to practise this specialty.

4. National and other special societies will eventually limit their membership to those who hold the Board's certificate.

5. The laity will gradually become informed of the importance of choosing specialists who are certified by the Board.

6. Physicians, in choosing consultants and in referring patients, will gradually turn to those who are certified and thus help to eliminate those who are not qualified to practise radiology.

The first examination will be held in Cleveland, Ohio, immediately preceding the meeting of the American Medical Association, in June, 1934.

The members of the Board are as follows:

H. K. Pancoast, M.D., *President*, Philadelphia.

A. C. Christie, M.D., *Vice-president*, Washington, D. C.

B. R. Kirklin, M.D., *Secretary-Treasurer*, Rochester, Minn.

E. C. Ernst, M.D., St. Louis.

G. W. Holmes, M.D., Boston.

E. L. Jenkinson, M.D., Chicago. Ill.

L. C. Kinney, M.D., San Diego, Calif.

W. F. Manges, M.D., Philadelphia.

L. J. Menville, M.D., New Orleans.

J. W. Pierson, M.D., Baltimore, Md.

L. R. Sante, M.D., St. Louis.

Henry Schmitz, M.D., Chicago.

Albert Soiland, M.D., Los Angeles, Calif.

M. C. Sosman, M.D., Boston.

R. H. Stevens, M.D., Detroit, Michigan.

All radiologists interested should write to B. R. Kirklin, M.D., Secretary, Mayo Clinic, Rochester, Minnesota.

RADIOLOGICAL SECTION OF THE LOS ANGELES COUNTY MEDICAL ASSOCIATION

The following are the present officers of the Radiological Section ot the Los Angeles County Medical Society: Orville Meland, M.D., *President;* Clayton Johnson, M.D., *Vice-president;* E. N. Liljedahl, M.D., *Secretary;* Henry Shure, M.D., *Treasurer.*

THE ZURICH CONGRESS

Word has just been received in this country from Zurich that up to Jan. 30, 1934, only twelve Americans had registered for the Fourth International Congress of Radiology at Zurich. At each one of the former Congresses, the United States has furnished not less than one hundred delegates and it is in all respects desirable that an equal number be present this year. We desire to call attention to the importance to American radiologists of a goodly representation. The program this year will be of unusual interest and scope.

All interested are urged to communicate at once with Dr. H. E. Walther, General Secretary, Fourth International Congress of Radiology, at Gloriastrasse 14, Zurich, Switzerland.

BOOK REVIEWS

COMPENDIO DI RADIOLOGIA MEDICA. PROF. G. B. CARDINALE and DOTT. MARIO MAINO. Preface by PROF. VITTORIO MARAGLIANO. A volume of 493 pages and 330 illustrations, with one colored table. Published by Ulrico Hoepli, Milan, 1934. Price, $4.00 (60 lire).

This Italian text-book on roentgen diagnosis, written especially for medical students and the general practitioner, presents the entire subject in a very detailed and practical manner. The text, which is replete with many fine illustrations, is arranged in eight parts which concern roentgen-ray technic, physics, and roentgen diagnosis as related to each of the various systems of the body. In the two concluding chapters the authors have discussed the clinical applications of roentgentherapy. In spite of the fact that this volume was written primarily for medical students and the general practitioner, as mentioned above, the text is most comprehensive and contains much that will interest the radiologist as well.

ROENTGENOTHERAPY IN TABLE FORM. DR. EMMERICH MARKOVITS, Chief of the Roentgenologic Laboratory in the State Hospital and Poorhouse in Budapest. A volume of 153 pages, with 40 figures; paper. Published by Georg Thieme, Leipzig, 1934. Price: M. 10.80.

In this German book Markovits has briefly stated a method of treating various lesions with roentgen rays. For those who desire a schematic tabulation of the method of roentgentherapy, this book contains much valuable information, but for the specialist it is not of much importance.

RADIODIAGNOSIS IN INFANTS: VOLUME I, PELVIS AND LOWER EXTREMITIES. By MANUEL and FRANCISCO ARCE, Radiologists to the Infant Jesus Hospital, Pediatric Clinic of the Faculty of Medicine of Madrid, and Asylum of San Rafael. Preface by DR. D. ENRIQUE SUNER, Ordinary Professor of Pediatrics, Faculty of Medicine of Madrid. A volume of 285 pages and 210 illustrations. Published by Ediciones Boro, Madrid, 1933. Price not stated.

This volume in which the authors review the roentgen pathology of the pelvis and lower extremities of infants is the first of a series of Spanish monographs to follow, concerning the roentgen pathology of childhood diseases. The first part of this monograph contains a complete description of the radiographic technic used and a discussion of the normal development and anomalies of the pelvis and lower extremities. The chapters which follow are devoted to a consideration of osseous lesions occurring in children. The syphilitic lesions which the authors classify as early and late manifestations are unusually well discussed and illustrated. The book contains many excellent illustrations and should prove useful to radiologists as well as pediatricians.

RADIOGRAPHIC STUDY OF THE NORMAL AND DISEASED BREAST. DR. ALEXANDRE ESPAILLAT-G., Faculty of Medicine of Paris, Certified Electro-radiologist of the Faculty of Paris. Work from the Surgical Clinic of Professor Gosset and the Clinico-radiologic Laboratory of the Faculty (Dr. Ledoux-Lebard, Chief of Staff). A volume of 154 pages and 18 illustrations. Published by Librairie Louis Arnette, Paris, France. Price: Not stated.

This is a complete and detailed French monograph concerning diseases of the breast.

The author has outlined the various anomalies of the human breast in a simple and clear-cut manner, so that the reader is able to grasp the radiologic manifestations quite readily. The radiographic technic is slightly different from that used in America in that the film is placed upon a block at an angle of 45° to the table, and the radiation passes through the breast and axillary structures at an angle of about 60°, judging from the illustration. He varies the quality of the radiation according to the pathology, and other anomalies present, and uses the stereoscopic technic.

He discusses, at considerable length, the normal female breast and changes brought about by menstruation and pregnancy and senility in the normal, and gives some most interesting illustrations of various non-malignant and malignant conditions. He also includes case histories of 41 patients in which the clinical, radiographic, and pathologic diagnoses (where possible) are correlated. The bibliography is complete.

The monograph is well worth reading for a complete review of the subject.

WILHELM CONRAD RÖNTGEN AND THE EARLY HISTORY OF THE ROENTGEN RAYS. By OTTO GLASSER, with a chapter entitled "PERSONAL REMINISCENCES OF W. C. RÖNTGEN," by MARGRET BOVERI, of Berlin. A volume of 494 pages and 96 illustrations. Published by Charles C. Thomas, Springfield, Ill. Price, $6.00.

This unusually interesting biography of Wilhelm Conrad Röntgen, by Glasser, begins with the dramatic discovery of the roentgen rays in 1895. The account of the discovery has been presented in an orderly and painstaking manner and the author has left no stones unturned to verify all statements. It should clear up many of the controversies now in existence, and in the future will undoubtedly be accepted as authentic. In the first chapter an interview with Röntgen by H. J. Dam, which appeared in "McClure's Magazine" in 1896, appealed to the reviewer as one of the high-lights of the book.

There is included in full the three communications of Röntgen concerning his discovery, together with the first impressions of the news of his discovery on the world. It would seem

that the various scientists could not be convinced of the importance of Röntgen's discovery until they had proof of its practicability as demonstrated by roentgenograms of the human hand. The practical application, as suggested by the pictures, immediately stimulated scientific and general interest and, except for them, the discovery might have been confined to the relative oblivion of the physical laboratory for some time.

The chapter on Röntgen's life is unusually comprehensive and very well written. It is unfortunate that his last years were made unhappy by the World War and by the economic collapse of Germany. At the time of his death his private fortune consisted of 339,000,000,000 paper marks and bonds with a value of 3,654 gold marks.

The accounts of Röntgen's discovery in the daily press and in popular magazines and in "Contemporary Humor" make very interesting reading, and show quite plainly that the lay mind was unable to grasp the true significance of the discovery.

The careful manner with which the author has verified all his statements indicates beyond question the reliability and authenticity of the biography. Especial mention should be made of the extensive bibliography and its orderly arrangement. The illustrations have been carefully chosen for their historic interest. Many of them are published in this book for the first time.

The radiologist who has not read this book has missed one of the outstanding contributions to x-ray literature.

THE VALUE OF ROENTGEN EXAMINATION IN PULMONARY DIAGNOSIS: A ROENTGENOLOGIC-ANATOMIC COMPARISON (Der Wert der Röntgenuntersuchung in der Lungendiagnostik Ein Röntgenolagisch-Anatomischer Vergleich). By TORLEIF DALE, from the Röntgen-Radium-Institut des Rikshospitalets, Oslo. Acta Radiologica, Supplement XVI, paper-bound volume, 111 pages with 57 illustrations, 14 of which are stereoscopic. Published by Kungl. Boktryckeriet, P. A. Norstedt & Söner, Stockholm, 1932. Price, Swed. cr 10.

In his foreword, Dale explains that the longer he studied pulmonary roentgenograms the greater were his doubts and uncertainty concerning their significance. His interest lies in the interpretation of the pathologic-anatomic substratum of pulmonary findings. He feels that in pulmonary roentgenography one is handicapped by the fact that confirmation of diagnosis usually must rest upon physical findings, not, as is often the case in other regions of the body, upon surgical or necropsy findings. He calls attention to the mechanical difficulties in pulmonary interpretation which result from the overlapping on the roentgenogram of certain parts of the lung parenchyma and the thoracic wall.

In 1928, the author began his comparative study of the lungs by means of pathologic-anatomic and roentgenologic examinations. He had as his goal the answers the answers to two questions: (1) What anatomic substratum have the changes which are found on the pulmonary roentgenogram? and (2) Which changes may be diagnosed on the pulmonary roentgenogram and which lie outside the diagnostic sphere of roentgen examination?

Dale's experimental work incorporated two processes. In the first his subjects were medical students with well-developed thoraces and of normal body weight. The procedure was as follows: first, the *intra vitam* injection of 50 c.c. of 40 per cent abrodil solution, and then stereo-roentgenograms of the lungs made during deep inspiration. His second study was upon roentgenograms of cadaver lungs made one to two hours after death. For this, he photographed the lungs *in situ* and then removed the lungs, heart, and neck organs together, with a clamp over the aorta and vena cava, and above the diaphragm. The excised lungs were then inflated by means of a blood pressure pump controlled by a manometer, and stereo-roentgenograms were made using the same factors as those used for the lungs *in situ*. Dale feels that roentgenograms should be made and the examination of pathologic material should be begun as soon as possible, generally not longer than twelve hours after death. This is essential to preclude *post-mortem* changes. His stereo-roentgenograms of excised lungs were made with the lungs placed upon a wooden board in which small steel wires were embedded so that they were projected onto the roentgenogram like a lattice. Later, when the lungs were frozen in the same position, the wires served as a guide for the comparative study of the specimen. To study the interlobar fissures, Dale used Kerr's paste inclosed within the fissures and subsequent photographs made in various directions.

This is a detailed method by which the author emphasizes some very valuable facts that have

been noted often by the American roentgenologists. The study of the lungs after death by air inflation and roentgenography is a procedure which has been used extensively in this country, and there have been reports of *ante* and *post-mortem* studies of the same cases. There have been numerous articles concerning the differential diagnosis of pulmonary cavities and the various types of tuberculosis, as well as constant stressing of the importance of continual comparison of necropsy material and roentgen findings. Dale refers to the confusion arising from superposition of vessel shadows. One American investigator carefully injected the blood vessels and air passages of the lungs after death, roentgenographed at each step of the process, and showed the possibility of error in interpreting these vessels as abnormal findings.

The article is documented with a well abstracted bibliography of 139 references, only ten of which, however, are from the American literature. The monograph is painstakingly written and represents great outlay of time and study.

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ARTHRITIS

Rheumatoid Arthritis. Russell L. Cecil. Jour. Am. Med. Assn., April 22, 1933, C, 1220.

The author presents a classification unanimously agreed on by a group of men especially interested in arthritis:

1. Infectious: (*a*) rheumatic fever; (*b*) rheumatoid arthritis; (*c*) arthritis caused by specific organisms.
2. Degenerative: Osteo-arthritis (hypertrophic arthritis).
3. Allergic: Serum sickness.
4. Traumatic
5. Metabolic: (*a*) gout; (*b*) scurvy; (*c*) rickets.
6. Neurogenic arthropathy, including syringomyelitis, Charcot's post-hemiplegia, etc.

He divides the subject into age groups.

Age 2 to 5 years, Still's disease.
Age 5 to 20 years, rheumatic fever.
Age 20 to 50 years, rheumatoid arthritis.
Age 50 to 70 years, osteo-arthritis.

Rheumatoid arthritis is primarily a disease of the synovial membrane and other soft parts of the joint, while osteo-arthritis is a disorder of the articular cartilage and adjacent bone. Cartilage and bone may become involved in the later stages of rheumatoid arthritis, while osteo-arthritis may be complicated occasionally by hydrops or by thickening of the synovial membrane. The anatomic differences are well brought out by radiography. In rheumatoid arthritis there is a haziness of the interarticular space and rarefaction of the bone. In the later stages the destruction of cartilage leads to close apposition and possible fusion of the articular surfaces. In osteo-arthritis, bony spiculation and hypertrophy of the articular margins are visible, even in the early stages. Later on, there is an increased osseous overgrowth at the joint margins, accompanied by degeneration and thinning of the cartilage. In osteo-arthritis, fusion of the articular surfaces does not occur. Rheumatoid arthritis is an inflammatory disease and its clinical course is that of an infectious process. Hypertrophy or osteo-arthritis appears to be a phase of senescence. It is possible that certain toxic or metabolic factors accelerate the process, but the picture is not that of an infection. The rational treatment of rheumatoid arthritis embraces removal of foci of infection, emphasis on rest, and a general building up program, consisting of carefully regulated diet, vitamins, iron and arsenic and adequate elimination through the intestine, bladder, and skin. Vaccines, physical therapy, and, in advanced cases, surgery are comprehensively reviewed as to their efficacy.

C. G. SUTHERLAND, M.D.

Visibility of the True Joint Space in Arthritis Deformans. G. von Pannewitz. Röntgenpraxis, November, 1933, V, 809, 810.

Roentgenograms of the knee joint, showing the true joint space without contrast filling, have been described by Dittmar. The author has seen the same phenomenon in five cases, four times in the knee and once in the shoulder joint. It has been thought that an especially favorable projection was necessary, but in the cases seen by the author the same picture could be reproduced without paying any attention to special positions. It was also evident that the joint space became more easily demonstrable in time. Often it is possible to see the menisci, just as they might be shown after air injection into the joint. All cases seen by the

author were suffering from an arthritis deformans. It seems reasonable to assume that the appearance of the true joint space might be due to an increased density of the cartilage of the joint, which might be based on pathologic changes. The subject needs further observation and study.

H. W. HEFKE, M.D.

BONES, ABNORMALITIES

The Os Epipyramis: Report of a Case. Albert B. Ferguson. Jour. Bone and Joint Surg., October, 1933, XV, 1001, 1002.

The author reports a case of the occurrence of the os epipyramis, an anomalous bone of the carpus. This anomaly had previously been described by Pfitzner, Dwight, Grumbach, and Heimerzheim. In the author's case the epipyramis was 2 mm. in diameter, oval in shape, and situated in the space between the left lunate, triangular, and hamate bones. There was no evidence of traumatism to this region.

J. N. ANÉ, M.D.

CONTRAST MEDIA

The Differential Diagnosis of Diseases of the Liver and Spleen by the Aid of Roentgenography after Intravenous Injection of Thorotrast (Thorium Dioxide Sol). Wallace M. Yater and Laurence S. Otell. Am. Jour. Roentgenol. and Rad. Ther., February, 1933, XXIX, 172–181.

For hepatosplenography, daily injections for three days are made, using each time 25 c.c. thorium dioxide solution (thorotrast). Films are taken with the patient in the anteroposterior and postero-anterior positions, any time after four or more hours following the third injection. Only three patients out of a series of 40 studied by this method had undesirable reactions. In the authors' opinion, indications for this method of investigation are: (1) any liver enlargement of unknown origin; (2) upper abdominal masses which might be liver or spleen; (3) clinical suspicion of liver abscess; (4) suspected metastatic carcinoma of the liver; (5) the existence of known hepatic disease, and the desire to follow its progress; (6) splenomegaly of unknown origin; (7) suspected ascites, and the attempt to prove its presence. Contra-indications are: (1) a moribund state of the patient from any cause; (2) known severe liver and kidney insufficiency.

Illustrations include cases of malignancy, cirrhosis, lobe anomalies, and ascites.

J. E. HABBE, M.D.

FOREIGN BODIES

Roentgen Diagnosis and Localization of Opaque Foreign Bodies in the Air Passages. Willis F. Manges. Am. Jour. Roentgenol. and Rad. Ther., March, 1933, XXIX, 368–383.

While the aspiration of foreign bodies into the bronchi is usually immediately accompanied by an attack of choking and later by recurrent attacks of coughing, the presence of the foreign body in the lung may remain unsuspected for months or even years, particularly in the cases of children. There is apt to be intermittent febrile reaction during which clinically there may develop bronchitis, pneumonia, abscess, or asthma. Of the many foreign bodies entering the respiratory tract, all but perhaps 2 or 3 per cent are retained indefinitely, this very small percentage being expelled spontaneously by coughing. The majority of foreign bodies, especially the opaque (metallic) ones, pass into the lower lobe bronchi. A localized infectious process, especially in the inner posterior portion of either lower lobe, should be looked upon as a reaction to a possible foreign body until other origin can be shown. A case of an adult with a shawl pin in a bronchus which the patient was completely unaware of having aspirated, is cited to emphasize that even adults may harbor foreign bodies in the lungs without being conscious of having aspirated them. Localization of an opaque foreign body in the absence of co-existing lung pathology is a relatively simple technical procedure. However, it is important that this procedure be carried out just prior to bronchoscopy because a definite percentage of these foreign bodies shift from one bronchus to another without creating any definite disturbance. Metallic foreign bodies may remain in the bronchi for years without producing extensive damage, yet on the other hand, some cases develop extensive infection, necrosis, and fibrosis. Rarely, perforation of the pleura may occur with the development of pneumothorax or pyothorax.

J. E. HABBE, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

The Clinical and Roentgenologic Diagnosis of Interposition of the Colon. M. J. Goldstein and Dm. Goldstein. Röntgenpraxis, December, 1933, V, 877–881.

The anomalous position of parts of the colon between the liver and the diaphragm, called interposition of the colon, is most often seen in persons of mature or advanced age: only rarely has it been reported in children. It may be temporary or permanent. In some cases there are no symptoms and the roentgenologic finding is accidental; in others, the interposition may lead to a number of cardiac symptoms, while in a third group this lesion is combined with gastric or duodenal ulcers. A few cases seem to be due to pleuro-diaphragmatic adhesions. In the differential diagnosis, sub-diaphragmatic abscess, spontaneous pneumoperitoneum, gas-filled intestinal cysts, and diaphragmatic hernia must be considered.

H. W. HEFKE, M.D.

Diverticula of the Colon and Their Complications. Ernst Schiffer. Röntgenpraxis, December, 1933, V, 865–877.

There are three groups of diverticula of the colon: (1) the true diverticula, the walls of which contain all

the layers of a normal colon and which are congenital (so rare that they are of no practical importance); (2) diverticulum-like sacculations after pericolitic adhesions, also of no clinical importance; (3) pseudodiverticula, which are really only herniations of the mucosa, but are commonly called diverticula. They are found mainly in places where blood vessels penetrate the muscular layer. Their etiology is not clear. Constipation, with increased pressure in the colon, local inflammatory processes, focal infection, congenital disposition, etc., have been said to be the causes. The roentgenologic demonstration of diverticula without clinical symptoms is a frequent occurrence (diverticulosis). Some authors acknowledge the existence of a prediverticulosis when the contour of the sigmoid is irregular and the transverse mucosa folds are increased. There might be one or many diverticula, most frequent in the sigmoid, next in the descending and transverse colon, and comparatively few in the ascending colon and appendix. A colitis diverticulosa or diverticulitis presents a typical roentgen appearance. There is spasm, change of the mucosa relief, and tenderness. An indurative inflammatory process may lead to an organic stenosis. Perforation of infected diverticula may cause localized abscesses or peritonitis, which require surgical measures. The roentgenologic diagnosis of diverticulosis (the only possible means of diagnosis) should mean the establishment of prophylactic measures, as anticonstipation diet, mineral oil, and so forth. The barium enema is much more reliable for the diagnosis of this disease than examination of the colon after a barium meal. Described in detail are 14 cases of diverticulitis, diverticulosis, and their complications.

H. W. HEFKE, M.D.

GENITO-URINARY TRACT (DIAGNOSIS)

The Value of the Roentgen Ray in the Diagnosis of Renal Tuberculosis. Charles A. Waters. Am. Jour. Roentgenol. and Rad. Ther., January, 1933, XXIX, 17–23.

It has been stated that the incidence of genito-urinary tuberculosis in postmortem examinations of individuals showing active or quiescent tuberculosis elsewhere may be as high as 10 per cent, males being involved about four times as frequently as females, and the right kidney about three times as often as the left. In a large majority of the cases of renal tuberculosis the original infection (usually in the respiratory tract) is quiescent and often not suspected.

X-ray evidence of renal tuberculosis is in the nature of either calcification in the renal cortex or of a "fringed" appearance of one or more minor calices upon pyelogram examination, the latter appearance being the result of tuberculous destruction of the tip of the papilla which lies in the cup of the calyx. Later fibrosis and strictures may also develop, alternating areas of narrowing and dilatation of the ureter. With recent hematuria, one must expect occasionally to see filling defects in the pelvis as a result of the blood clot. In the author's series of 35 cases, 70 per cent showed positive pyelographic findings, while 40 per cent showed areas of cortical calcification. It is believed that there are no contra-indications to this method of investigation when properly performed.

J. E. HABBE, M.D.

HEART AND VASCULAR SYSTEM

Roentgen Therapy of Rheumatic Heart Disease: A Review of Six Years' Experience. Robert L. Levy and Ross Golden. Am. Jour. Roentgenol. and Rad. Ther., January, 1933, XXIX, 79–82.

The authors report on their results of radiation therapy for rheumatic heart disease. By using single fields, anteriorly and posteriorly, they attempt to deliver 10 per cent of a skin erythema dose through the heart region, using penetrating rays generated by 200 K.V. (peak) through 0.5 mm. copper. Such radiation is repeated at intervals of two weeks until four such series have been given.

During the last five and three-fourths years, 32 patients have been treated by this method. In 17, improvement has been observed, while five cases show striking relief of paroxysmal angina. Patients in the first attack of rheumatic fever, with slight cardiac involvement, offer the best chance for successful therapy by this method.

J. E. HABBE, M.D.

THE KIDNEYS

Carbuncle of the Kidney (Metastatic Staphylococcus Abscess of the Kidney). William N. Taylor. Am. Jour. Surg., December, 1933, XXII, 550–556.

Carbuncle of the kidney is accepted as a distinct pathologic and clinical entity, a localized phlegmon of the kidney. There are no clinical symptoms or physical findings which differentiate it from other hematogenous infections of the kidney. The diagnosis is difficult but is suggested by the presence or antecedence of a superficial staphylococcal infection, usually of the skin. Trauma has seldom been recorded as playing an important rôle in its production.

Herein is reported a case in which there was no antecedent infection—there was a definite history of trauma, a microscopic hematuria, a pyelogram which showed pelvic distortion, and an incorrect diagnosis of renal neoplasm. Treatment consisted of nephrectomy, with complete recovery.

DAVIS H. PARDOLL, M.D.

PEPTIC ULCER (THERAPY)

A Case of Large Non-malignant Gastric Ulcer and a Case of Large Duodenal Ulcer, with Fatal Hemorrhage. George N. Burger and Paul Merrell. Jour. Am. Med. Assn., Feb. 4, 1933, C, 336.

A case of gastric ulcer in a patient, aged 58, who had given a history of 33 years of aching or "tearing pain"

in the epigastrium is reported. At autopsy a stomach ulcer was found, measuring 6 × 11 cm., extending to within 2 cm. of the pylorus. Microscopic examination showed no evidence of neoplasm.

The other case reported is that of a duodenal ulcer in a male, aged 64, who, 30 years before, had been treated for peptic ulcer, for which he had been hospitalized for nine months. He was well until six weeks before the present admission, when he developed severe epigastric pain, nausea, and vomiting within from 15 to 20 minutes after meals, loss of appetite and hiccoughing. Death followed, and autopsy showed a large ovoid ulcer, 1 cm. from the pylorus, measuring 2.5 × 5 cm., with distinctly indurated edges, perforated on to the pancreas. Both patients presented advanced arteriosclerosis. C. G. SUTHERLAND, M.D.

THE PROSTATE

Choice of Procedure in Cases of Prostatic Obstruction. N. P. Rathbun. Am. Jour. Surg., October, 1933, XXII, 106–112.

The author stresses the fact that prostatism provides us with a wide variety of problems—we have available a wide variety of methods of treatment and it devolves upon us to make every effort to elect a procedure which is best adapted to each individual case.

He realizes that a larger quantity of statistical evidence would probably be more convincing, yet his paper is more or less a philosophic contemplation rather than a statistical analysis of the entire problem. He expresses his personal views upon a few of the moot points in an effort to provide a suitable groundwork upon which to base a profitable discussion.

This is a most excellent article, without over-enthusiasm for any single procedure, and well worth while reading.

DAVIS H. PARDOLL, M.D.

RADIATION EFFECTS

Shifting of Pigment in the Nipple following Roentgen Treatment. E. Saupe. Strahlentherapie, 1933, XLVI, 397, 398.

A man 59 years of age was treated over the anterior upper mediastinum, the right lower corner of the field reaching the right nipple. Several months after the first treatment there was a marked increase in pigmentation in that part of the right nipple which was within the exposed area, while pigmentation from the remaining part of the nipple had almost disappeared.

ERNST A. POHLE, M.D., Ph.D.

The Influence of Roentgen Rays on the Action Current of Nerves. W. Schmitz and H. Schaefer. Strahlentherapie, 1933, XLVI, 564–567.

The action current in the ischias nerves of frogs under the influence of roentgen rays was studied by the authors. Doses up to 1,000 r per minute and a total dose of 5,000 r were used (110 K.V., 10 ma., 20 cm. field, 1 mm. Al). No direct primary influence on the nerve from doses as used in therapy could be detected.

ERNST A. POHLE, M.D., Ph.D.

Roentgen Therapy of Neuralgia of the Trigeminus. Rudolf Hummel. Strahlentherapie, 1933, XLVII, 684–688.

During the period from 1922 to 1932, 36 patients were treated in the author's clinic for neuralgia of the trigeminus. Technic: 160 K.V., 4 ma., 30 cm. F.S.D., 0.5 mm. Al, 6 × 8 sq. cm. field of entry over the temporal area, 200–250 r per sitting to be repeated three times at eight-day intervals. Twenty-seven cases were used in the statistics of end-results. Five (18.6 per cent) patients were cured; in another like group there was marked improvement, and in 40.6 per cent of the patients there was temporary improvement lasting from four to twelve months. In six cases (22.2 per cent), the treatment was not successful.

ERNST A. POHLE, M.D., Ph.D.

Effect of Roentgen Rays on the Cholesterol Metabolism and its Compensation by Lipoid Feeding by Mouth. Magda Kiesel. Strahlentherapie, 1933, XLVI, 311–342.

The cholesterol content of the plasma was studied in rabbits and humans before and after irradiation, with and without cholesterol feeding. Although the findings did not point in one direction, the author feels that one may expect a cholesterol drop after roentgen irradiation. This is usually followed by roentgen sickness. If cholesterol is given by mouth, it is often possible to avoid the systemic reaction. Emphasis is laid upon the fact that no difference in the behavior of the cholesterol content could be seen between patients with and without carcinoma.

ERNST A. POHLE, M.D., Ph.D.

Roentgen Therapy in Furunculosis of the Face. W. Baensch. Strahlentherapie, 1933, XLVII, 188–194.

The author studied the effect of roentgen rays on furunculosis of the face by comparing 103 patients which were treated with 103 untreated controls. Conservative treatment of non-irradiated furuncles of the face had a mortality of 10.7 per cent, while irradiated patients showed only 1.9 per cent mortality. In 87 per cent there was a definite beneficial effect of irradiation. The pain subsided and within a few hours after exposure the temperature dropped to normal and the course of the illness was materially shortened. The majority of the cases received 150 r through 1.5 Zn + from 3 to 5 mm. Al at 30 cm. distance; sometimes a dose of as much as 250 r was applied.

ERNST A. POHLE, M.D., Ph.D.

The Present Status of Roentgen Therapy of Nonmalignant Diseases in Women. C. J. Gauss. Strahlentherapie, 1933, XLVII, 144–159.

The author discusses briefly the use of roentgen rays

in the following conditions: uterine fibroids, uterine hemorrhage, disturbances during pregnancy, and sterilization, temporary as well as permanent. Small doses applied to the ovaries and the effect of roentgen rays in inflammatory diseases are also mentioned. The author discusses the use of radiation in diseases of the vulva followed by indications for exposing hypophysis, thyroid, thymus, spleen, liver, breast, kidneys, bladder, and finally the vegetative nervous system.

ERNST A. POHLE, M.D., Ph.D.

Folliculitis with Pseudo-tumor Formation in a Patient with Radio-epidermitis Sicca. G. Schwarz and A. Frank. Strahlentherapie, 1933, XLVII, 195–200.

A patient 77 years of age, with carcinoma of the left tonsil, was observed following x-ray therapy in high doses (5,300 r) over the cervical areas. The left side received the higher dose and showed marked reaction. That on the right was milder, but directly below the mandible there appeared a plum-sized swelling which started to ulcerate at the surface. A tentative diagnosis of metastases in the glands was made, but tissue curetted from the surface did not show malignant cells. Within a week the growth had reduced considerably in size and the necrotic area healed. Therefore, it must have been a folliculitis which was naturally mistaken for a malignant involvement of the gland.

ERNST A. POHLE, M.D., Ph.D.

RADIATION SICKNESS

Roentgen Sickness and its Treatment with Cardiazol-ephedrin. Waldemar Hug. Strahlentherapie, 1933, XLVII, 708–714.

The author recommends Cardiazol-ephedrin in solution or in the form of tablets (1 tablet = 1 c.c. = 0.1 g. Cardiazol + 0.015 g. ephedr. hydrochlor.) for the treatment of roentgen sickness. In a series of 50 cases it proved to be most effective.

ERNST A. POHLE, M.D., Ph.D.

Liver Extract in the Treatment of Roentgen Sickness. F. G. Dietel. Strahlentherapie, 1933, XLVIII, 110–113.

The author states that in 15 female patients the symptoms of x-ray sickness disappeared within an hour after injection of from 2 to 4 c.c. of liver extract.

ERNST A. POHLE, M.D., Ph.D.

RADIUM

Morbidity and Mortality in Radium Treatment of Carcinoma of the Uterus. E. Wagner. Strahlentherapie, 1933, XLVII, 651–657.

In the author's clinic 127 patients (114 with carcinoma of the cervix and 13 with carcinoma of the fundus) were treated with 322 radium applications. In 62 instances a slight elevation of the temperature was noted, and 16 times high temperature was observed for a longer period of time. There was not a single case of death in this series.

ERNST A. POHLE, M.D., Ph.D.

Radium Therapy of Circumscribed Keratosis. Herbert Fuhs. Strahlentherapie, 1933, XLVIII, 194–198.

The author treated 280 cases of clavi with radium. In eight cases the lesion was on the dorsum of the toes and in twelve at the lateral aspect of the toes, none of which responded to treatment. Of the entire group, 29 had lesions between the toes and three of those were cured (10 per cent); 231 had lesions on the plantar surface and 98 per cent of these were cured. He also reports on 154 patients with verruca. He treated 46 cases of verrucæ planæ juvenilis, with 39 lesions on the face and seven on the hands. In the first group, 80 per cent and in the second location 71 per cent were cured. The second group of verrucæ vulgaris subdivided into lesions around the nail and those in other parts of the body, particularly the face and hands. In the first subdivision numbering 29, 93 per cent showed a cure, and among 79 belonging to the second subdivision 67 per cent responded to the treatment. Radium therapy of clavi and verruca is, therefore, the method of choice. The author used from 50 to 100 mgh. at 1 cm. distance, filtered through 0.3 Pt or beta radiation applying 1 mgh. per square centimeter of lesion.

ERNST A. POHLE, M.D., Ph.D.

Biologic Dosimetry for Radium Preparations. O. Jüngling and H. Langendorff. Strahlentherapie, 1933, XLVIII, 174–186.

The radiation emitted from radium preparations was studied with biological methods, for instance, the effect of *Drosophila* eggs. Quite irregular distribution of radio-activity over the surface was seen in many instances. To quote one example, three 10-mg. gold needles furnished by the same company with the same order showed the following variations: Two had the highest radio-activity at the point of the needle and diminished toward the other end; the third needle, however, had its maximum emission in the center.

ERNST A. POHLE, M.D., Ph.D.

Radium Therapy in Carcinoma of the Lip. Edmund Kelly. Jour. Am. Med. Assn., Feb. 11, 1933, C, 388–390.

For carcinomas of the lip radium therapy stands preeminently as the method of choice. This is an analysis of the cases of 535 patients suffering from carcinoma of the lip for the years 1913 to 1931. The author has taken as representative of the success of irradiation those cases treated during the years 1921–1929, inclusive. Since 1921, an increasing proportion of patients in whom the lesion was still localized or the glandular enlargement moderate has been referred for

radium; also, since that year a more standardized method of application and calculation of dosage has been established. Diagnosis in every case was made by a man experienced in carcinoma of the lip.

The answer to the question as to whether or not radium is an effective treatment for cancer of the lip is that, regardless of allowances, deductions, and comparative statistics, the fact remains that 200 patients with definite carcinoma of the lip, some moderate, some extensive, a few even with glandular metastases, were treated by radium alone, and out of these 200 primary cases there remain 133 patients living and well without recurrence two years after treatment, and of 99 cases treated five years or more ago, 72 patients were living and well five years after treatment. The disease is one that is easily recognizable before it has become extensive locally or has metastasized (82 per cent of the primary cases show no palpable metastases); therefore, one might reasonably expect to get practically all cases while they are still in the curable stage and by irradiation cure over 90 per cent without hospitalization.

C. G. SUTHERLAND, M.D.

SCIATICA

The Significance and Treatment of Sciatic Pain. Winchell McK. Craig and Ralph K. Ghormley. Jour. Am. Med. Assn., April 15, 1933, C, 1143.

From a diagnostic standpoint one should consider constitutional or systemic disease conditions, such as diabetes, syphilis, and gout; and the forms of toxic neuritis which develop secondary to absorption of lead, arsenic, or alcohol. Tumors of the spinal cord have been known to cause unilateral pain for many years before the development of additional symptoms which would indicate the diagnosis. Bilateral sciatic pain, or a condition in which pain is severe enough to require morphine, suggests tumor of the spinal cord or meninges. Neurofibromas along the course of the sciatic nerve may give rise to sciatic pain. Metastatic or primary tumors pressing on the lumboscral plexus may have as their initial symptons unilateral sciatic pain. A sciatic syndrome occasionally develops in certain vascular diseases. Various observers suggest that idiopathic or primary sciatica is caused by inflammatory reactions about the roots which go to form the sciatic nerve, and that sciatica is due to arthritis of the spinal column involving the nerves traversing the foramina or distal to the ganglions. Anomalies of the spinous processes and laminæ and spina bifida occulta are rarely the cause of sciatic pain. Anomalies of the articular facets may often be contributory factors. Lumbosacral strain or arthritis with changes in the articular facets or in the lumbos sacral intervertebral discs may be a causative factor particularly in the lower lumbar region. The fact that sciatic pain does occur in sacroiliac conditions must be accepted, although it cannot as yet be explained satisfactorily. A comprehensive review of the methods of treatment follows.

C. G. SUTHERLAND, M.D.

THE SKULL (DIAGNOSIS)

The Formation of Osteophytes in the Skull and Their Practical Significance. F. Leeser, B. Ostertag, and A. Horwitz. Röntgenpraxis, May, 1933, V, 331–335.

Osteophytes are osseous outgrowths on the internal aspect of the skull in the region of the frontal bone; the etiologic factors are not known. They are well known to pathologists and have been found in 4.3 per cent of autopsy material (Dressler). The formation of osteophytes takes place usually in advanced age—in the average case at 70 years. The female sex shows them much more often than does the male. For roentgenologic demonstration occipitofrontal and lateral roentgenograms (preferably stereograms) are necessary. One may see irregular, sometimes fairly well circumscribed areas of increased density, on the internal aspect of the frontal bone, which may be rather extensive and of nodular type. Calcification or ossification of the falx may be misleading in lateral roentgenograms, but an postero-anterior film allows the differentiation. Another type is characterized by its map-like symmetrical appearance. On the lateral view one can recognize a dense homogeneous shadow which protrudes considerably in connection with the convexity of the frontal bone. The occipitofrontal view is typical: one sees usually symmetrical, cloud-like, overlapping areas of increased density in the region of both frontal bones. From a differential diagnostic standpoint, tumors of the dura with calcification, calcifying endotheliomas, psammomas, gummas, etc., must be considered, but homogeneity, situation, and sharp limitation of the osteophytes usually permit a correct interpretation. Osteitis fibrosa localisata is less sharply defined and shows areas of bone absorption, with areas of bone apposition. Moreover, the entire bone (also the external table) is attacked. Osteomas originate in the tabula externa and are unilateral. Clinically, formation of osteophytes is of no significance; however, their recognition is important for diagnostic reasons.

H. W. HEFKE, M.D.

THE SPINE

Vertebral Epiphysitis and Osteochondritis. Paul O. Snoke. Jour. Bone and Joint Surg., October, 1933, XV, 963–968.

The author reviews the writings of Scheuermann and Schmorl and presents three cases of dorsal kyphosis, classified as follows: One case of true vertebral epiphysitis; one case of osteochondritis, and one case of vertebral epiphysitis associated with severe osteochondritis.

Some confusion exists relative to these conditions. While Scheuermann is a clinician, Schmorl is a pathologist and the author believes that Schmorl saw the termination of the disease Scheuermann described. There is also a possibility that three or more separate diseases or manifestations of the same condition may exist. Evans suggested the following pathologic entities: (1) Vertebral epiphysitis (Scheuermann); (2)

osteochondritis of cartilaginous interface (Schmorl); (3) a combination of these two.

The author's paper is illustrated by roentgenograms from the three cases he reports.

J. N. Ané, M.D.

Prespondylolisthesis: Its Roentgenographic Appearance and Clinical Significance. Samuel Kleinberg. Jour. Bone and Joint Surg., October, 1933, XV, 872–881.

In the study of congenital lesions of the spine which are known to be important etiologic factors in disturbances and disability of the lumbosacral area, the author believes that prespondylolisthesis also should be considered as a possibility. This condition may be described as a congenital bilateral laminar defect of the last lumbar vertebra without displacement of its segments.

The recognition of prespondylolisthesis is important because it has been proved a definite cause of backache and back disability, which by appropriate treatment can be cured, and also because, in the author's opinion, it precedes spondylolisthesis or actual subluxation of the vertebral body. The detection and proper treatment of prespondylolisthesis, therefore, will prevent the occurrence of spondylolisthesis.

Clinically, these patients complain of weakness and low back pain, aggravated by physical activity and relieved by rest and support of the back. Other symptoms noted were stiffness of the back and sciatic pain. Physical examination may reveal lumbar lordosis, and tenderness to pressure at the lumbosacral junction.

The lateral roentgenogram reveals the pathology. This shows a vertical or slightly oblique defect in the pedicles between the articular processes of the last lumbar, separating the body and superior articular processes in front from the inferior articular processes and neural arch posteriorly. There is no displacement of the segments, although the author found exaggeration of the lumbosacral angle in over half of the cases.

The treatment of this condition is surgical and consists of a fusion of the lower three lumbar vertebræ to the sacrum.

J. N. Ané, M.D.

The Dark Stripes in the Roentgenograms of Bechterew's Disease. Kurt Ehrlich. Röntgenpraxis, May, 1933, V, 347–352.

If one studies the roentgenograms of a spine affected with Bechterew's disease, one notices two dark longitudinal stripes on both sides in the region of the small vertebral joints. In the advanced stage of the disease another longitudinal stripe is seen—often with interruptions—which represents unquestionably the ossified ligamentum apicum or supraspinale. The other two stripes have been explained by ossification of the ligamenta intertransvercaria by Krebs. Fischer and Vontz believe that they are due to an ossification of the ligaments of the intervertebral joints and the ligamenta flava. By pathologic, anatomical, and experimental studies the author reaches the conclusion that the bony tissue about the diseased joints and on the joint processes becomes denser, superimposed on a film in such a way as to cause a continuous stripe of increased density. Occasionally the bonified ligamentum anterius, situated just in front, tends to increase the density.

H. W. Hefke, M.D.

THE SPLEEN

Hereditary Gaucher's Disease. J. P. Anderson. Jour. Am. Med. Assn., Sept. 23, 1933, CI, 979–981.

Gaucher's disease, according to the present conception, may be defined as a non-hereditary congenital familial disease due to a disturbed lipoid metabolism, with the production of an abnormal substance (kerasin). This is stored by histocytes of reticulo-endothelial origin, giving rise to the typical Gaucher cell, which is found in all tissues, chiefly the spleen, lymph glands, liver, and bone marrow, in which reticulo-endothelium is present. Clinically the disease is characterized by splenomegaly, hepatomegaly, pigmentation of the skin, pinguecula-like thickenings of the ocular conjunctivæ, hemorrhagic diathesis, unique changes in the bones with discrete or confluent rarefactions, leukopenia, anemia of the hypochromic variety, thrombocytopenia, and, in infants, there may be a preponderance of neurologic symptoms. About the only constant symptom is the enlarged spleen. The age of onset or first discovery varies from birth to 32 years. The course may be acute in children; is usually chronic in adults. The condition commonly is slowly progressive, the patient living for 20 years after the disease has been detected. While it is familial, there is no reported transmission from adult to child.

C. G. Sutherland, M.D.

TENDONS

Stiff, Painful Shoulders, Exclusive of Tuberculosis and Other Infections. Edson B. Fowler. Jour. Am. Med. Assn., Dec. 30, 1933, CI, 2106–2109.

Rupture of the supraspinatus tendon is apparently the primary exciting cause of most "stiff, painful shoulders," and early recognition, with prompt proper treatment, will bring about much earlier and better end-results. Codman found a complete rupture of the supraspinatus tendon to every twenty shoulders examined, and one incomplete rupture to every third shoulder. He believes that virtually every rupture is caused by the contraction of the supraspinatus muscle and that tears are rarely produced by direct trauma.

C. G. Sutherland, M.D.

THE THORAX

Tuberculous Pericarditis: Its Roentgenologic Significance. Karl Kornblum, Samuel Bellet, and Herman W. Ostrum. Am. Jour. Roentgenol. and Rad. Ther., February, 1933, XXIX, 203–213.

The x-ray diagnosis of tuberculous pericarditis de-

pends upon: the demonstration of pericardial pathology (usually in the form of effusion); the demonstration of pericardial adhesions (usually at the base); the demonstration of tuberculous disease in the lungs or elsewhere in the body, and finally the demonstration (upon correlation) of the clinical data compatible with the diagnosis of tuberculous pericarditis. For the demonstration of pericardial adhesions at the base, it is helpful to inject from 300 to 400 c.c. of air immediately after aspirating the fluid as completely as possible, a procedure which also makes possible a more accurate determination of the heart size. The authors also feel that examination in the erect and recumbent positions will show less change in contour of the cardiac shadow at the base than in the usual case of non-tuberculous pericardial effusion. Tuberculous pericardit is estimated to occur in 4 per cent of all tuberculous patients. The article is clearly illustrated.

J. E. HABBE, M.D.

Roentgen Diagnosis of Interlobar Pleurisy. Charles A. Waters. Internat. Clinics, II, Series 43, 195–201.

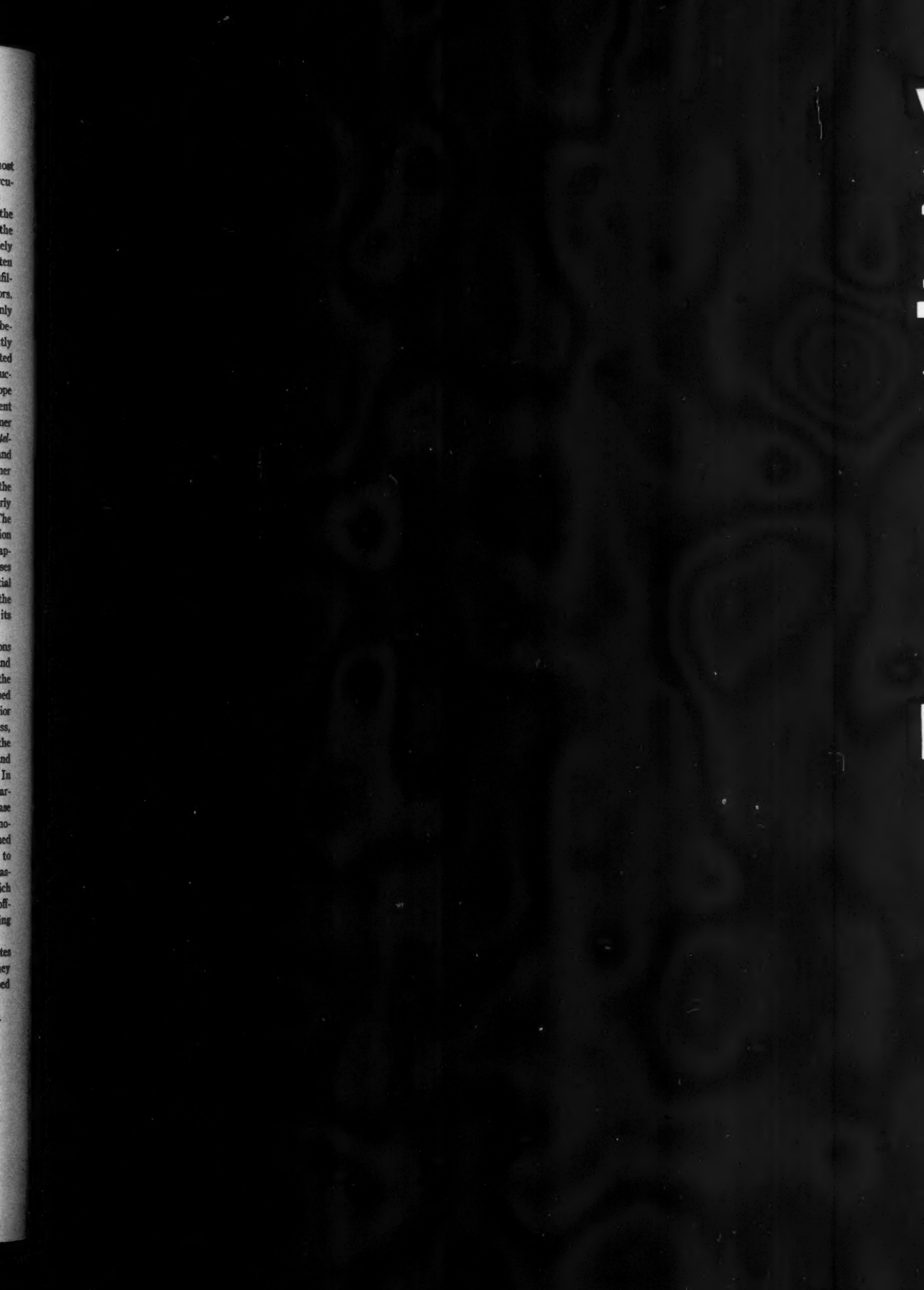
The author discusses the importance of films made tangentially to the various fissures of the lungs and of the lateral view in addition to the routine postero-anterior view of the chest, in the roentgen diagnosis of interlobar pleurisy. He believes that interlobar exudates are far more common than generally suspected, but that when properly used, the roentgen ray seldom fails to reveal the extent and type of the pathologic process.

The fissure in the left lung starts at the hilus, extends upward to the posterior wall, and laterally and anteriorly downward, the direction of its course corresponding roughly to a line drawn from the third thoracic vertebra to the sixth costochondral junction. The portion of the lung which lies above this line is the upper lobe, while that below is the lower lobe. On the right, there is one main fissure and one accessory fissure. While the main fissure runs relatively the same course except that it is a little more vertical, the accessory fissure begins in the main fissure near the posterior border of the lung, in the region of the posterior axillary line, and running horizontally forward cuts the anterior surface of the lung on a level with the fourth costal cartilage. The upper and middle lobes of the right lung correspond to the upper lobe of the left.

Interlobar pleurisy may result from any inflammation of the tissues contiguous to the interlobar pleura, or from extension inward from the free plural cavity of pleural effusions or empyema following pneumonic processes, or pulmonary tuberculosis in adults. The mediastino-interlobar type of pleurisy which has its origin in the hilus of the lung is most commonly an accompaniment of mediastinal tuberculosis in children but may occur also in adults.

In the ordinary postero-anterior projection of the chest only effusions or fibrosis in the fissure between the upper and middle lobes on the right can be definitely visualized. Effusions in the oblique fissures are often misdiagnosed as consolidations, tuberculous infiltrations, bronchiectases and even early lung tumors. A lateral view will give the desired information only when the pleural thickening or exudate extends beyond the mediastinum toward the chest wall sufficiently far to cast a shadow which can be clearly differentiated from those shadows due to the mediastinal structures. The author advises the use of the fluoroscope to determine the correct position in which the patient should be placed in making the films. Fleischner first called attention to the so-called *"Kreuzhohlstellung,"* in which the patient rests with the neck and shoulders against the film in a semi-inclined manner and steadies himself by holding to the frame of the support, thereby stretching his abdomen anteriorly and producing a marked concavity of the spine. The exposure is made antero-posteriorly. In this position the plane of the large oblique interlobar spaces approaches the horizontal so that the central ray passes through the entire extent of the fissure in a tangential direction. Illustrations are included demonstrating the position, as well as roentgenograms illustrating its value in the roentgen study of this condition.

The differential diagnosis of many similar conditions will be simplified if it is remembered that exudates and thickenings in the oblique fissure, when viewed in the *"Kreuzhohlstellung,"* reveal wedge- or spindle-shaped shadows with sharply outlined superior and inferior borders. On the other hand, a pneumonic process, with the exception of complete consolidation of the middle lobe, ceases abruptly at one of the fissures and presents an irregularity at one of its borders. In complete consolidation of the middle lobe the appearance would be a triangular shadow with its base against the chest wall, and subsequent roentgenograms would show rapid alteration. Sharply defined tumors of the middle lobe will prove more difficult to differentiate. The lateral view may prove of some assistance by showing a spindle-shaped shadow which is sharply outlined on all sides, but in which the offshoot of the spindle corresponds to the remaining fibrosed fissure.

The author believes that these interlobar exudates continue for a very long period of time, and, when they are simple effusions, they may eventually be absorbed and leave a residue of thickened pleura.

J. N. ANÉ, M.D.